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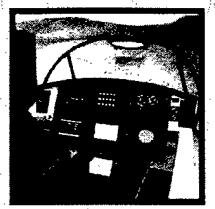
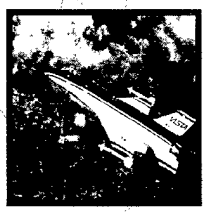

WRIGHT LABORATORY SUCCESS STORIES

A REVIEW OF 1996

AIR FORCE SCIENCE & TECHNOLOGY

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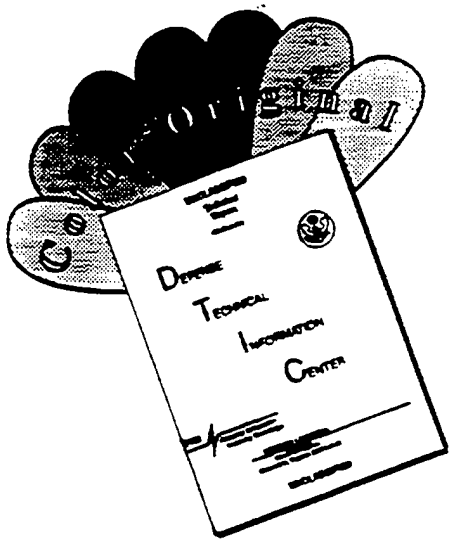

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WRIGHT LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT PATTERSON AFB OH 45433-7523
POC: MICHAEL GROMOSIAK, WL/DOR (937) 255-4119

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SUCCESS STORIES FROM 1996 THAT RECOGNIZE THE ACCOMPLISHMENTS AND COMBINED EFFORTS OF WRIGHT LABORATORY SCIENTISTS AND ENGINEERS. STORIES HAVE BEEN SELECTED FROM THE FOLLOWING CATEGORIES: TECHNOLOGY TRANSITION--TECHNOLOGY THAT HAS ACHIEVED APPLICATION ON A DOD SYSTEM IN DEVELOPMENT OR OPERATION; TECHNOLOGY TRANSFER--TECHNOLOGY TRANSFERRED FROM THE LABORATORY TO THE PRIVATE SECTOR; TECHNICAL ADVANCEMENT --MAJOR INNOVATIVE TECHNOLOGICAL ADVANCEMENTS THAT OFFER SIGNIFICANT POTENTIAL FOR EXISTING & FUTURE AF SYSTEMS; AND, PEER RECOGNITION--EXTERNAL AWARDS OR RECOGNITIONS BY THE SCIENTIFIC COMMUNITY AT LARGE, CONCERNING ADVANCEMENTS IN TECHNOLOGY TRANSITION, TRANSFER OR TECHNICAL ACHIEVEMENT.

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A Message About Wright Laboratory Success Stories

The Wright Laboratory takes its name from the "fathers of aviation", Wilbur and Orville Wright. We trace our heritage to an experimental engineering station established at McCook Field in 1917. As we approach our 80th anniversary we look back with pride on our accomplishments; the aeronautical architects at Wright Laboratory have created technology advances that have enabled our Air Force to establish and maintain its acknowledged position as the most technically advanced and capable in the world. Today we pursue vital aerospace research and advanced developments in aero propulsion and power, armament, avionics, flight dynamics, integrated manufacturing and materials. We are committed to meeting the needs of our fighting forces while offering "dual use" potential in the commercial sector.

We are proud of our people and the teams they have formed, not only to do world-class research but also to transition that technology to meet our customers' needs. In recognition of their accomplishments, each year we highlight some of the best and brightest of our laboratory efforts with "Success Story" profiles. These brief profiles of ongoing research and development projects offer a snapshot look at the breadth and depth of ongoing work at the Air Force's Wright Laboratory. I invite you to explore just a little of the diverse, exciting and innovative work ongoing at the Wright Laboratory during 1996.

Should you see a Wright Laboratory "Success Story" you want to know more about, I hope you will contact us so we might share the details. Also, take a moment to check out our home page on the world wide web (at http://www.wl.wpafb.af.mil).

Richard W. Davis
Colonel, USAF
Commander
Wright Laboratory

WRIGHT LABORATORY
SUCCESS STORIES

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INTRODUCTION

Over 360 Air Force Science and Technology "Success Stories" from the Air Force's Wright Laboratory have been presented over the past seven years. The individual stories most often represent the combined effort of several scientists and engineers working as a team. The basic and applied research, plus the follow-on technology development described in a "Success Story", are viewed as essential to the continued success of the Wright Laboratory mission.

This year's "Success Stories" were selected from one or more of the following categories:

TECHNOLOGY TRANSITION: Technology that has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations (see Table I).

TECHNOLOGY TRANSFER: Technology that has transferred from the laboratory to the private sector, to include: industry, academia, and state and local governments (see Table II).

TECHNICAL ACHIEVEMENT: Major innovative technological advancements that offer significant potential for existing and future Air Force systems (see Table III).

PEER RECOGNITION: External awards or recognitions by the scientific community at large, concerning technology advancements in the areas of Technology Transition, Technology Transfer or Technical Achievement (see Table IV).

To receive more information on the "Success Stories" contained in this document by the experts involved, or to learn about other activities at Wright Laboratory, please contact: WL/DOR, 2130 Eighth Street, Suite 1, Wright-Patterson AFB OH 45433-7542, Tel. (937) 255-4119 or fill-in, and send us the reply card located in the back of this brochure.

TABLE I. TECHNOLOGY TRANSITION SUCCESS STORIES

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TABLE I. TECHNOLOGY TRANSITION SUCCESS STORIES (CONT'D)

TABLE II. TECHNOLOGY TRANSFER SUCCESS STORIES

TABLE III. TECHNICAL ACHIEVEMENT SUCCESS STORIES

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TABLE III. TECHNICAL ACHIEVEMENT SUCCESS STORIES (CONT'D)

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TABLE IV. PEER RECOGNITION SUCCESS STORIES

1996 Wright Laboratory Success Stories


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Methodology Quantifies Manufacturability of New Aircraft Structural Design

Payoff

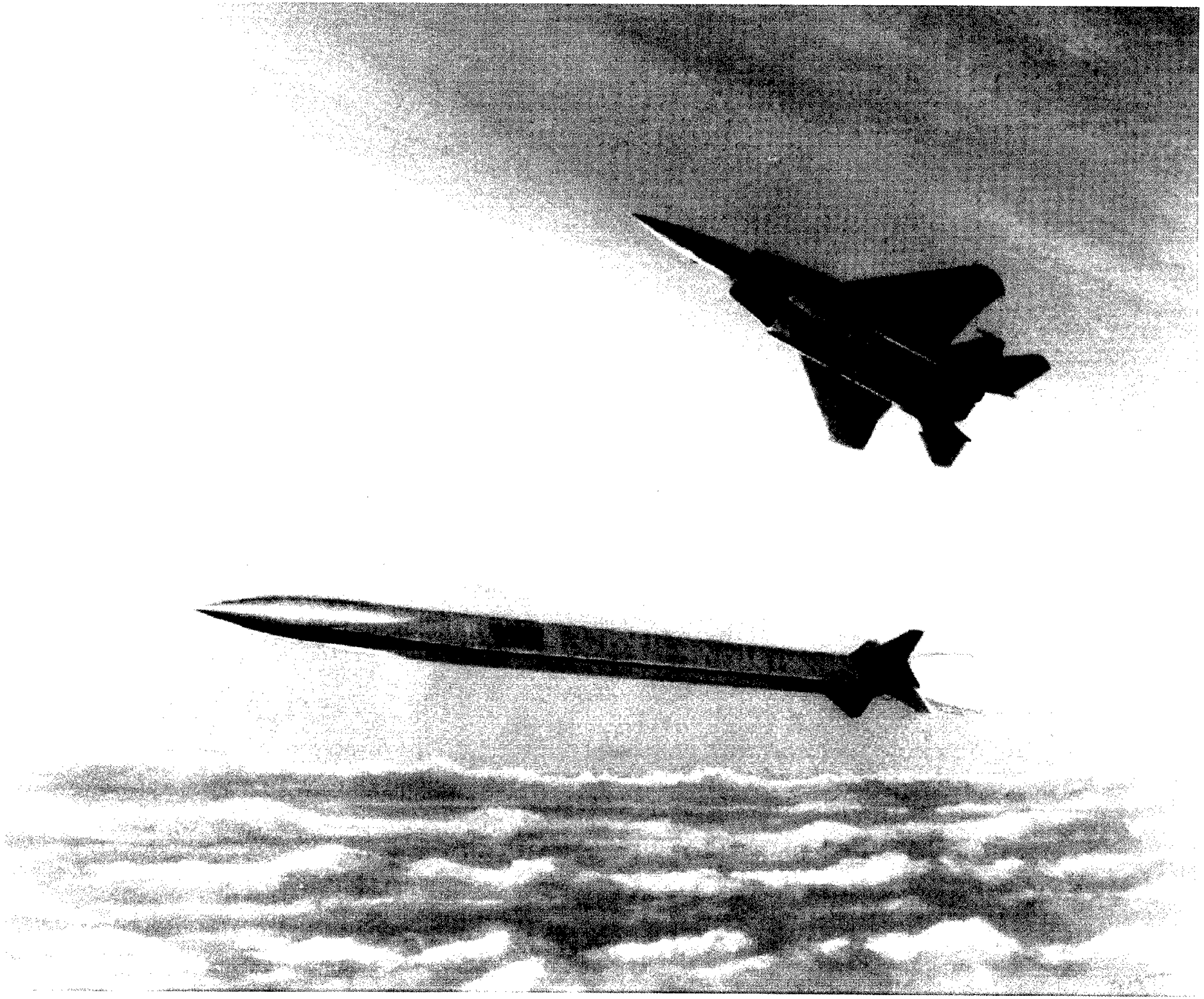
By addressing variation related assembly problems for complex structural assemblies up front, integrated product teams (IPTs) can reduce fabrication and inspection costs, reduce production schedule risks, improve interchangeability, identify necessary process improvements and increase quality and first-time yields. Components of the process capability methodology were used in the redesign of the C-17 engine pylons saving an estimated $13,000 per aircraft or $1.1 million over the current fleet.

Accomplishment

Under a program sponsored by the Manufacturing Directorate, McDonnell Douglas developed a methodology that provides the ability to predict whether or not complex aircraft structural design assemblies will meet specifications prior to initiating production. It enables IPTs to consider process capability information in evaluating the manufacturability of new designs, as well as, troubleshoot existing designs.

Background

Blanket tolerances coupled with inattention to tolerance analysis during product definition are major contributors to poor control of manufacturing costs. To address these problems, a method widely accepted by the auto industry was expanded to consider process capability information in evaluating the manufacturability of complex aircraft structural assemblies. It uses a commercially available, three-dimensional tolerance analysis tool called Variation Simulation Analysis (VSA) in conjunction with dimensional process capability information, to assess the impact of process variation on the form and fit of a complex structural assembly such as an F/A-18C/D leading edge flap. By collecting detailed process capability information and applying that information to VSA, an IPT is able to quantify the variation inherent in a structural assembly and determine the major contributors to the assembly level variation. Employing a five-task approach, engineers initially relate critical assembly characteristics of the final assembly to subassembly and detail part features. A measurement plan is then developed to gather process capability information, which coordinates the measurements between the final assembly, subassembly and detail part features. In the second task, the desired variability measurements are obtained. This includes surveying existing statistical process control information, developing detailed quality plans and measurement instructions, and conducting gage repeatability and reproducibility studies. The third task consists of taking hundreds of measurements while trying to coordinate efforts with the demands of a production schedule. Measurement templates are developed and manufacturing personnel trained. This raw measurement data is then analyzed and reduced into process/feature capability data. Concurrently, the assembly is simulated in VSA, first using engineering tolerances, and then using the reduced process/feature capability data.



State-Dependent Riccati Equation Technique Solves Nonlinear Control Problems

Payoff

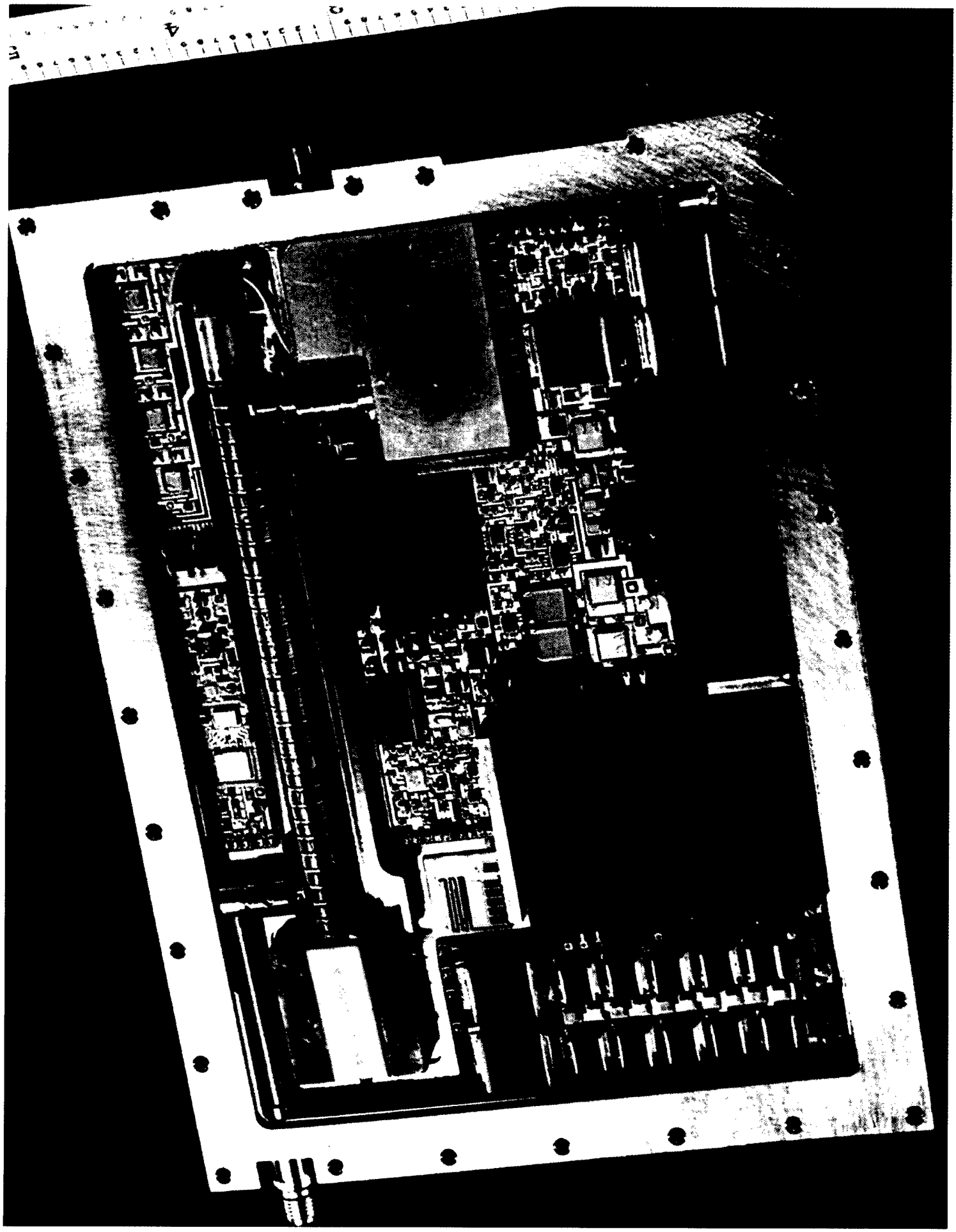
With demonstrated application to missile guidance and target estimation, this revolutionary technique has led to the development of advanced guidance algorithms. It will significantly increase the performance of missiles in high dynamic environments and provide better estimates of a missile's position. These improvements result in a significant reduction in missile miss distance.

Accomplishment

The Armament Directorate's Navigation and Control Branch developed a novel approach to nonlinear control and estimation that provides the capability to solve nonlinear control problems in feedback form. The guidance laws derived using the State-Dependent Riccati Equation Technique have shown a factor of ten improvement in missile miss distance and an increase in intercept velocity when evaluated in a six degree-of-freedom missile simulation.

Background

The State-Dependent Riccati Equation Technique will revolutionize the approach to nonlinear control and estimation in the same way that state space methods and Kalman filters changed linear controls research from the early 1960s to the present. In simulations, this nonlinear method for solving nonlinear regulator and nonlinear estimator problems has provided a factor of 10 improvement in missile miss distance. The nonlinear estimator is expected to further reduce the miss distance because of the superior estimate of the target maneuver. Missiles and aircraft can benefit from the new estimator methodology, since the new navigation filters will directly incorporate dynamic and measurement nonlinearities. With proper tuning, navigation accuracy for tactical and navigational grade inertial measurement units may potentially improve by a factor of ten without having to change hardware. This will enable current tactical grade inertial measurement units, with already exceptional drift rates of 1 to 10 degrees per hour, to achieve drift rates of 0.1 to 1 degree per hour using the same inexpensive sensors. Similar improvements in aircraft navigation are also possible. All control algorithms which were based upon the assumption of linearity must now be reexamined in light of this advancement in nonlinear control. The new algorithms are being considered for the Air Force's Advanced Medium Range Air-to-Air Missile and the Army's Patriot Missile Batteries.



Compact Microwave Power Module Provides Affordable High Efficient Power

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Payoff

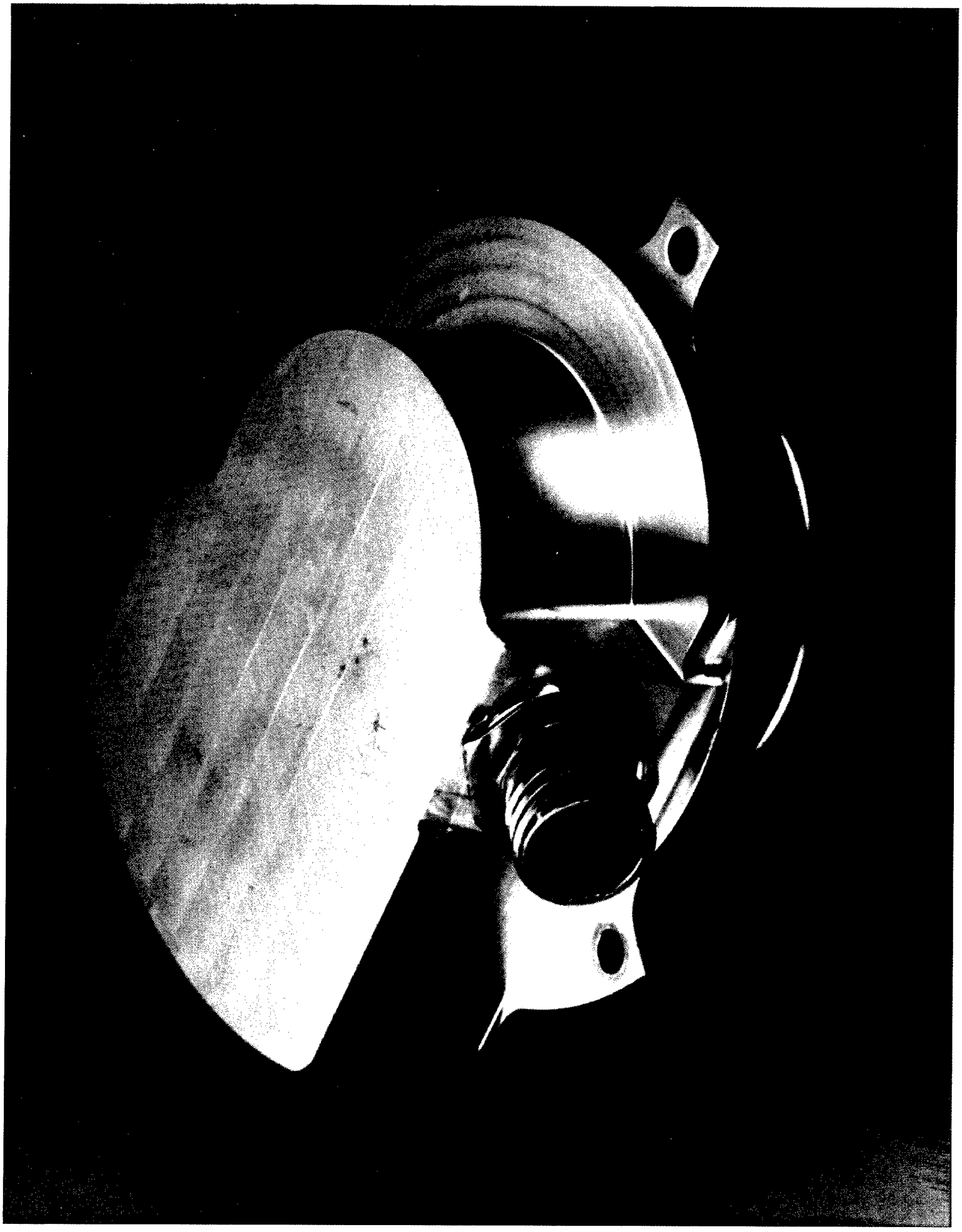
The microwave power module is capable of providing power over wide bandwidths at high efficiencies. Its small size and affordable cost make it ideal for a wide range of military applications including radar, electronic warfare and communication systems.

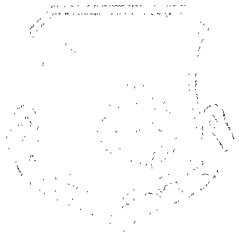
Accomplishment

The Solid State Electronics Directorate's Microwave Division developed a microwave power module (MPM) that achieved a frequency range of 6 to 18 gigahertz (GHz), overall efficiencies of 35 to 40% and a power density of 13.33 watts/in^3 . The power provided over wide bandwidths at high efficiencies is an order of magnitude greater than solid-state power amplifiers (SSPAs) and traveling wave tube amplifiers (TWTAs).

Background

A MPM is a hybrid device that incorporates a solid state driver, vacuum electronics power booster and integrated power conditioning. Initial MPM projections indicated that a compact high performance microwave transmitter technology base could be developed that would provide the following advantages: a greater than fourfold improvement in efficiency over SSPAs alone; greater than 30 dB improvement in noise over TWTAs; and a tenfold reduction in size over current generation TWTAs. When compared to fielded military systems, MPMs are one-tenth the volume and one-sixth the weight with 2.5 times the radio frequency (RF) output power and 5 times the efficiency with improved reliability. With the integration of a power conditioner within a common package, multiple MPMs can be combined to produce a highly reliable transmitter with graceful performance degradation. Traditional transmitters have large TWTs, high voltage power supplies and modulators as separate assemblies. The Solid State Electronics Directorate's MPM program addresses the basic needs of the Department of Defense for compact, lightweight, affordable RF transmitters. Its technology is being transitioned for use in airborne electronic warfare systems, airborne and unmanned air vehicle data links, synthetic aperature radar transmitters and towed decoys.





New Electronic Safe and Arm Device will Improve Advanced Medium Range Air-to-Air Missile (AMRAAM) Reliability

Payoff

The Electronic Safe and Arm Device (ESAD) will dramatically improve the safety and reliability of the AMRAAM safe and arm capabilities. It is the first Air Force non-nuclear, all-electronic, in-line safety and arming device selected for engineering and manufacturing development. With replacement scheduled to begin with all Lot 12 missiles, the new ESAD becomes the standard safe and arm device for all future AMRAAM missiles.

Accomplishment

Wright Laboratory's Armament Directorate developed, fabricated and tested an advanced ESAD that is safer, more reliable, and more easily produced than the current AMRAAM electro-mechanical device. This all-electronic design reduces arming tolerances by approximately half. This results in more accurate arming distances, thereby increasing the margin of safety for the launching aircraft.

Background

This advanced safe and arm device was developed by the Directorate under the Programmable Ordnance Technology (PROTEC) program, a development effort which focused on three subsystems: the electronic safety and arming device, the warhead, and a target detection device. Of the three subsystems, the ESAD was accepted by the Air Superiority Program Office (AMRAAM JSPO). The PROTEC program started with a basic design developed by Sandia National Laboratories; however, the original design and specifications required modifications to meet the current AMRAAM requirements. Following the Armament Directorate's successful development and testing of a design that met AMRAAM requirements, the Program Office awarded a contract to the missile's prime contractor for engineering and manufacturing development of the ESAD. The prime contractor selected Motorola, the PROTEC contractor, and the PROTEC design to accomplish this development effort. The ESAD has a feature which allows the arming distance to be drastically extended, based on the missile launch/engagement scenario. This feature further increases the safety of the launching aircraft. This new design also adds the first ever capability to independently monitor the status of the three safing devices in the all-up fuze configuration. Earlier versions of AMRAAM may benefit from these enhancements if certain retrofits are performed. Per unit costs for the device are expected to be less than the costs associated with the current electro-mechanical device, when the innovative production test capability incorporated into the ESAD design is utilized. The modular design of the ESAD will allow repeated testing of the electronic circuitry during production and life-cycle surveillance testing with all explosive devices removed.

FedEx

NEW FORCED-AIR™ DE-ICING SYSTEM CUTS COSTS

Payoff

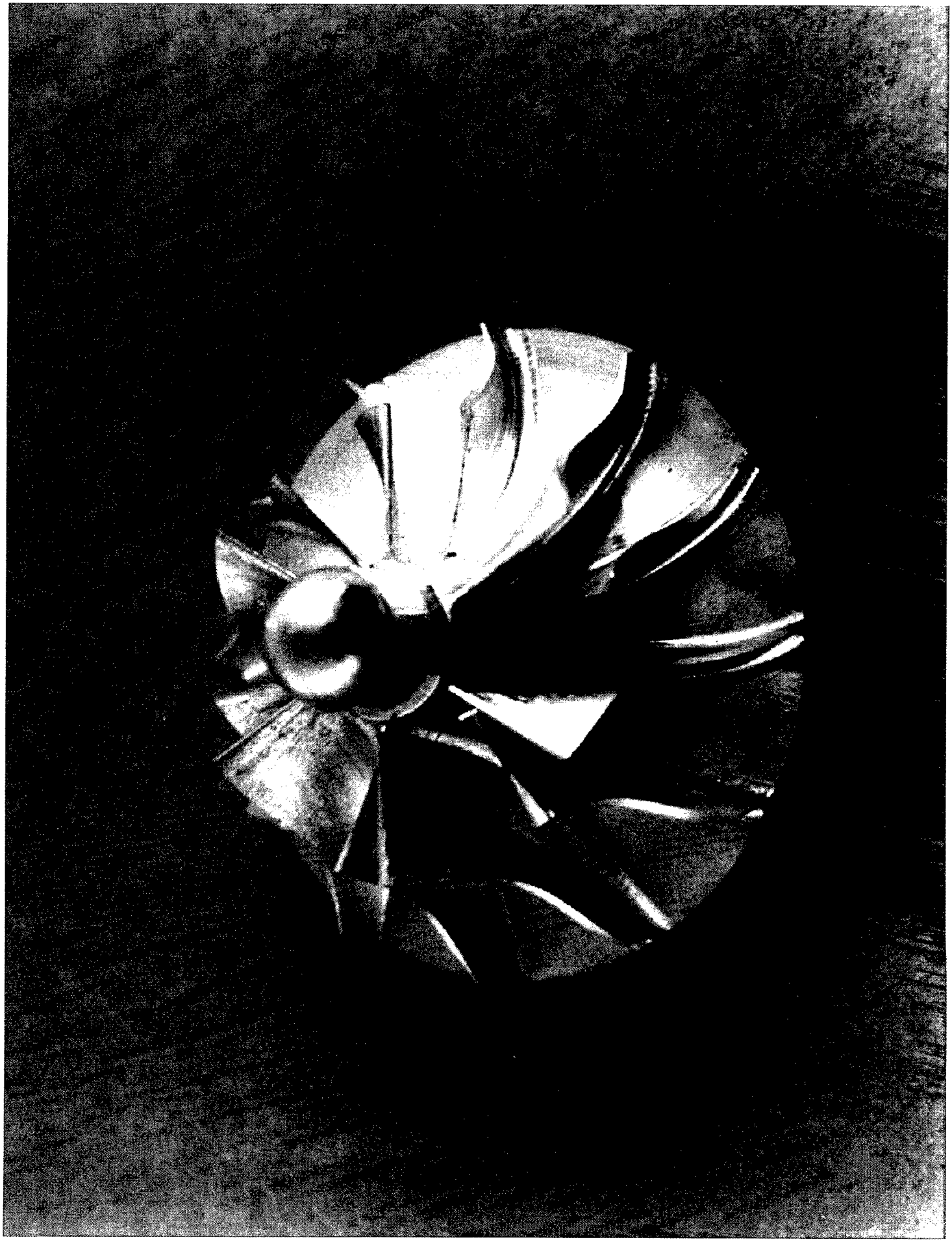
The FORCED AIR™ de-icing system uses compressed air combined with a fine spray of glycol de-icing fluid to blow snow and ice off of aircraft wings and to prevent new ice formation. Compared to traditional "fluid only" methods, this new system has potential to de-ice wings in half the time, while using at least 70 percent less glycol per aircraft. This reduction in glycol usage not only minimizes pollution, but also allows the system to pay for itself within one season.

Accomplishment

Under a Cooperative Research and Development Agreement (CRDA) between the Flight Dynamics Directorate and Aviation Environmental Compliance (AEC) Inc, Kettering OH, an improved nozzle configuration and compressed air system for an aircraft de-icer system was developed. The system, patented by AEC, is a self-contained, truck-mounted unit which removes snow and ice from aircraft surfaces by a high pressure air jet combined with a fine spray of glycol to prevent new ice formation. This CRDA was administered by technology transfer specialists of the Wright Technology Network of Dayton OH.

Background

The Federal Aviation Administration has instituted stricter rules governing the de-icing of aircraft. This has spurred the development of new de-icing equipment and methods to reduce the use of glycol - a chemical used for de-icing that has been placed on the Environmental Protection Agency's hazardous materials list. The performance of AEC's FORCED AIR™ de-icer system avoids the expense and pollution associated with the glycol de-icing process. This retrofit kit for use on de-icing trucks includes a hose, nozzle, a steering device for the nozzle and an engine with an air compressor. Its performance upgrade, performed under the CRDA by the Flight Dynamics Directorate, included an improved blower system. The nozzle and hose was redesigned and a more efficient, but less expensive, air compressor was installed. This was accomplished following successful tests of a prototype at United Airlines Denver Stapleton Airport terminal during the winter of 1993-94. AEC was recognized for this accomplishment when they received the 1995 Emerging Technology Award from the Ohio Department of Development.



High Efficiency Centrifugal Compressor Encourages Environmental Compliance Through Reduced Energy Costs

Payoff

Increasing the efficiency of lubrication free centrifugal compressors will significantly decrease energy costs and increase military and commercial applications for centrifugal compressor heat pumps. Utilization of environmentally friendly refrigerants will increase compliance to environmental regulations.

Accomplishment

Under the Lubrication Free, Magnetic Bearing, High-Efficiency Centrifugal Compressor program sponsored by the Aero Propulsion and Power Directorate, an innovative, lightweight, lubrication free refrigeration compressor that can be used with new non-ozone-depleting refrigerants was developed. The efficiency for this low flow rate centrifugal compressor was increased from 60% to 80%. Compressor efficiencies approaching 90% are achievable.

Background

The Lubrication Free, Magnetic Bearing, High-Efficiency Centrifugal Compressor program's technological heritage is in the Directorate's previous spacecraft heat pump efforts. These previous efforts, funded through the Small Business Innovation Research Program, included the demonstration of magnetic bearing technology. Mainstream Engineering Corporation of Rockledge FL coupled this technology with their computer-aided design/manufacturing (CAD/CAM) design of a new compressor wheel to develop the lubrication free refrigeration compressor. Their CAD/CAM approach resulted in the fabrication and test of the compressor wheel design in days instead of the previously required months. Removal of the oil from the refrigeration system increases refrigerant stability. In the pure state, proposed environmentally safe alternative refrigerants remain relatively stable to temperatures up to 370°C. The presence of oil lowers the stability limits to below 100°C. Eliminating oil from the compressor allows for the well known vapor compression heat pump to be used. The vapor compression heat pump remains the most efficient refrigeration and air conditioning cycle available.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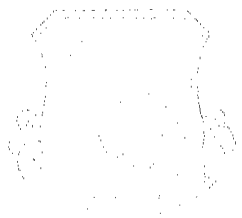


AUTOMATED ORDNANCE EXCAVATOR PERMITS SAFE UNEXPLODED ORDNANCE REMOVAL

Payoff

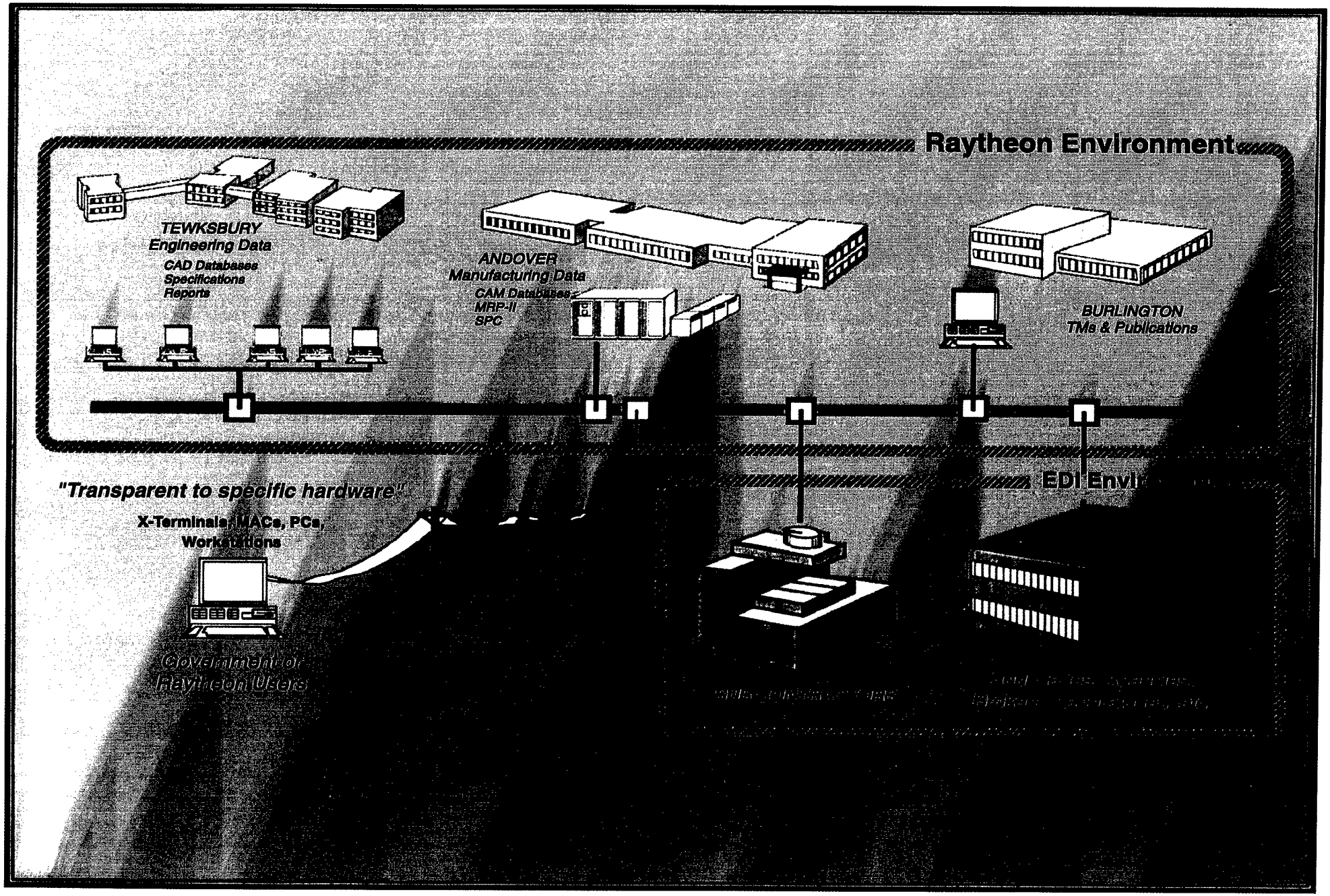
The ability to remotely navigate an excavator precisely over unexploded ordnance (UXO) eliminates the need to expose Explosive Ordnance Disposal personnel to the hazardous environment of impact/bombing ranges. Remote operation provides the capability to remove the operator from the cab and associated hazardous conditions, while providing a "birds-eye" view of the digging area. Autonomous survey vehicles for remote control excavation of UXO will enable land released by the military to the private sector to be safely utilized.

Accomplishment

The Flight Dynamics Directorate's Air Base Technology Branch developed an Automated Ordnance Excavator (AOE) with a navigation system capable of positioning the AOE within centimeters of a given latitude/longitude target location. Its long-reach boom/stick assembly enables a remote operator, via video feedback, to reach forward 60.5 feet from the base of the excavator to dig to depths as great as 48.5 feet to uncover and remove ordnance.

Background

Test and target ranges contain buried UXO such as bombs, mines, submunitions, missiles and rockets. Many of these ranges will be turned over to civilian control as a result of base closures and realignments. Before such land can be used for private endeavors, it must be rid free of UXO. The Department of Defense established the Jefferson Proving Ground Unexploded Ordnance Advanced Technology Demonstration Program to establish a baseline of the state of the art in subsurface detection, identification and remediation of UXO. The Air Base Technology Branch is developing platforms/ technologies that support the UXO and area clearance programs. This work is being accomplished under the sponsorship of the Army Environment Center at the direction of the Naval Explosive Ordnance Disposal Technology Division. The Branch's AOE is their first autonomous survey vehicle developed for site characterization and remote control excavation of UXO. The main component of the AOE is an off-the-shelf, "long-reach" excavator with a remote control system. The "long-reach" boom/stick assembly keeps the excavator base as far away as possible in the event of a detonation. A remote control unit is installed on the excavator which can manipulate the functions normally performed by an on-board operator including boom, stick, bucket, swing and driving control via radio link. An auxiliary mechanical thumb is installed at the bucket for grasping a UXO for safe removal. Several cameras provide the remote operator the necessary video feedback for safe and effective control of the excavator. A computer generated map displaying the entire work area depicts topographical features, potential target locations and the position of the excavator in a "real-time" situation. Given the latitude/ longitude coordinates of a UXO, the AOE utilizes a Differential Global Positioning System satellite input to travel directly to the hazard and locate a target within centimeters.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New Program Equips Subcontractors with Latest Computer-Aided Tools

Payoff

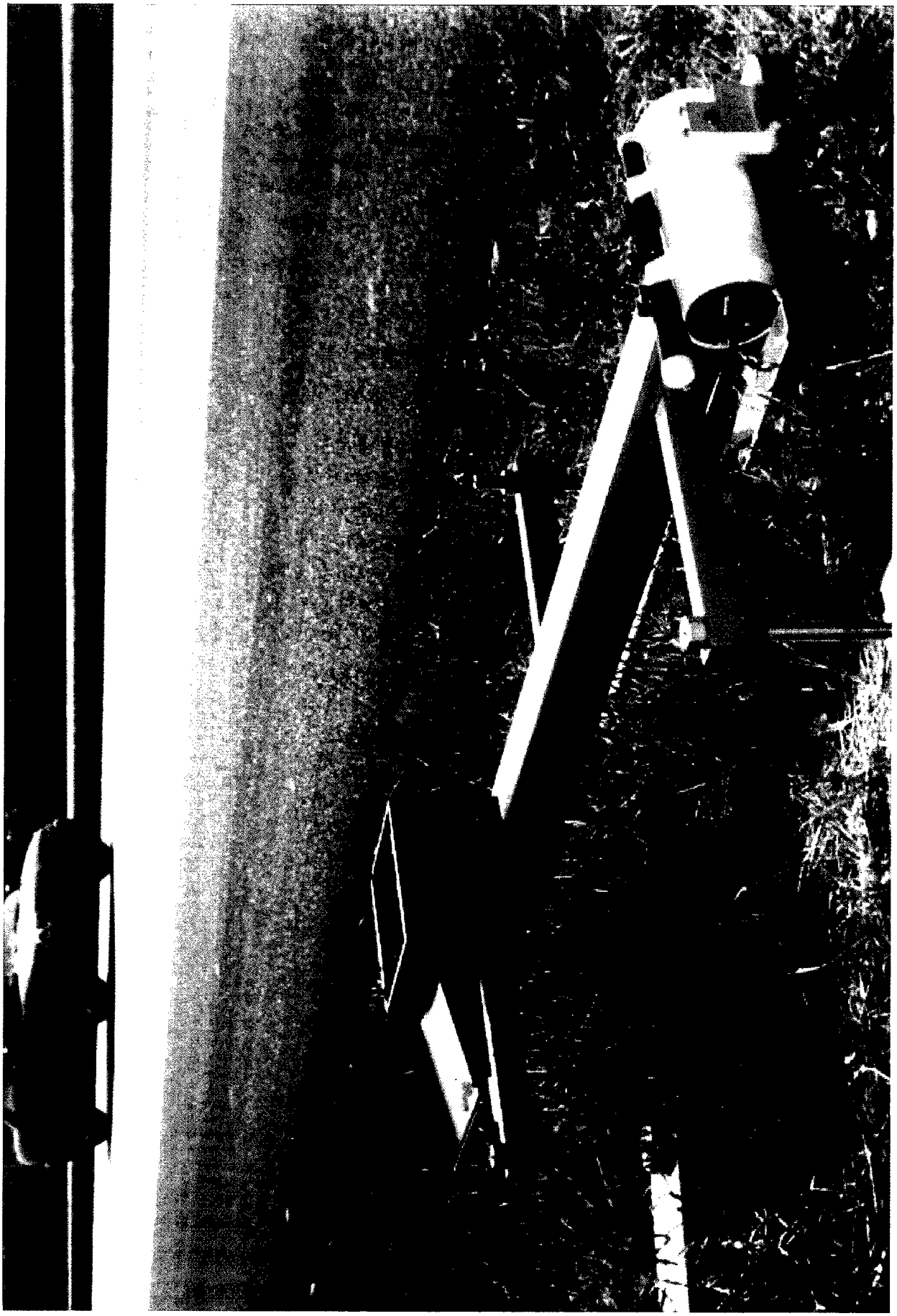
With new software tools available to subcontractors, this program has proven the potential to reduce subcontractor production costs by 34 percent, and subcontractor bid preparation costs by 21 percent. These savings do not take into account the enormous potential savings in propagating engineering changes through the supply chain.

Accomplishment

Under a program sponsored by the Manufacturing Technology Directorate's Industrial Base Pilots Integrated Program Team, engineers at Raytheon developed a computer software system that provides subcontractors access to prime contractor computer-aided manufacturing and design tools and databases. This system equips subcontractors with the same computer software resources used by the prime contractor that are normally cost-prohibitive to smaller subcontractors.

Background

Many large manufacturers significantly reduce production costs through investments in computer-aided design and manufacturing (CAD/CAM) systems and associated electronic databases. Subcontractors play a vital role in the production of any weapon system, accounting for a larger portion of each system's cost and substantially affecting product quality. Unlike prime contractors, many small subcontractors, due to limited financial resources, do not have access to the latest computer-aided tools. Even subcontractors with their own systems find compatibility with the prime contractor is uncertain at best. Engineers at Raytheon, in conjunction with A&A Tool and Die Company of Lynn MA, have developed a software system providing controlled access to appropriate prime contractor CAD/CAM tools and databases. The Vertical Partnering Subcontractor Facilitization program effectively equips the subcontractor with the same resources used by the prime contractor. A derivation of Raytheon's Manufacturing Integrated Technical Information Service, the vertical partnering system acts as supply chain integrator, providing access to data managers, data files and appropriate tools as if they were resident on the subcontractor's computer system. At the same time, an extensive security subsystem protects Raytheon's parent systems from any unauthorized access. The vertical partnering system also lists potential designs for bidding. The subcontractor can select a potential job, access a database copy and use the prime contractor owned CAD/CAM tools to estimate the bid. If chosen, they can use the database and tools again to generate machining and inspection data files for downloading into their own computer systems. Additionally, reporting of statistical process and quality controls data is possible with tools made available through the system.



REMOTE TRAFFIC MONITORING SYSTEM

Payoff

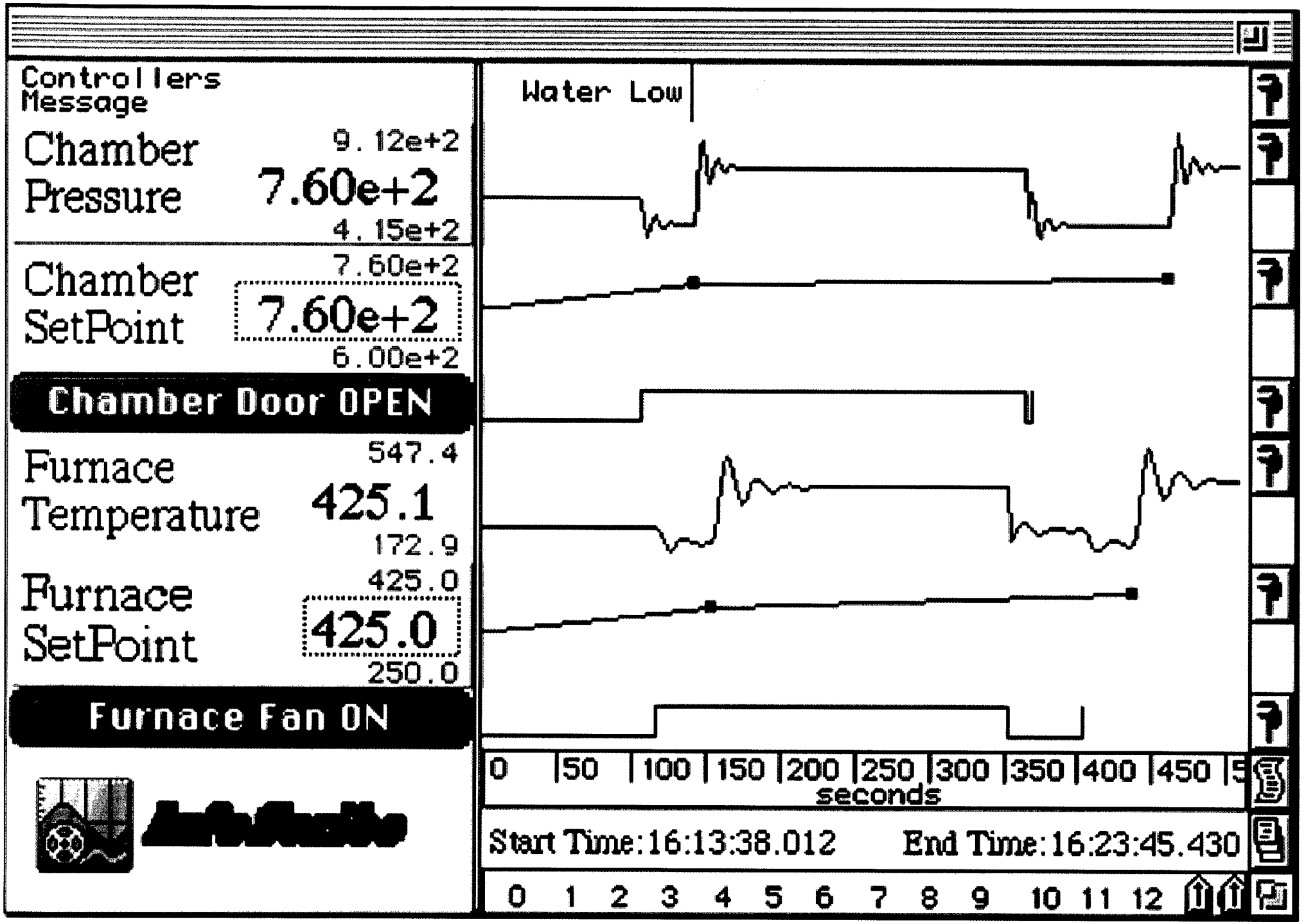
The remote traffic monitoring system can be installed safely on the side of the road without disturbing traffic. This low cost sensor system can collect data and monitor traffic in remote locations, as well as provide for growth in both the Federal Highway Administration and the Ohio Department of Transportation (ODOT) requirements for traffic monitoring.

Accomplishment

Wright Laboratory's Avionics Directorate through the Small Business Technology Transfer (STTR) program (complement to the Small Business Innovation Research Program) designed, developed, tested and demonstrated an advanced traffic monitoring system for ODOT. This new system uses laser sensors that are installed on the roadside to count and monitor traffic. It can be used at permanent locations, or as a portable unit at remote sites for short term traffic data collection.

Background

Currently, ODOT uses traffic monitoring systems that consist of inductive loops, piezo switches and road tube sensors to monitor traffic flow. The systems are installed at 5000 sites to detect the number of axles, vehicle length and lane location in order to collect and record traffic count, classification and speed data. Installations are permanent, portable or manual. When permanent installations are not included when the highway is built, the systems must be installed later during traffic flow at greater expense. When major road repairs are made at a permanent installation site, the monitoring systems must be replaced at additional costs. ODOT expressed a need for a low cost, nonintrusive traffic monitoring system that is safe to install. The key requirements included the capability to classify by lane the vehicle type (by axle), the capability to monitor one to four lanes of traffic, and the capability to measure vehicle velocity within two to five miles per hour. Additional requirements included packaging each system as a self-contained portable unit that can be set up in less than 30 minutes, cost in the range of $2000 to $4000, and exhibit the capability to communicate, electronically, from remote sites to a command center.


Controllers
Message
Chamber
Pressure
9.12e+2
7.60e+2
4.15e+2
Chamber
SetPoint
7.60e+2
7.60e+2
6.00e+2
Chamber Door OPEN
Furnace
Temperature
547.4
425.1
172.9
Furnace
SetPoint
425.0
425.0
425.0
Furnace Fan ON
Water Low
0 50 100 150 200 250 300 350 400 450
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End Time:16:23:45.430
0 1 2 3 4 5 6 7 8 9 10 11 12

InfoScribe™ Process Information System Improves Quality and Affordability of Advanced Materials

Payoff

Development of the InfoScribe™ information system has eliminated many drawbacks associated with conventional materials processing systems. Its modular design allows for the processing of higher quality and more affordable materials, provides flexibility in system design and avoids the necessity of developing a completely new system for every material process. These improvements will assist both government and industry in reducing costs, system development time and production time for various material processes.

Accomplishment

The Materials Directorate developed a process information system that improves the quality, precision and reliability of materials processing systems. Their InfoScribe™ system supports a range of materials processing systems with various hardware configurations, modules and data communication formats while maintaining compatibility with embedded research apparatus software. The InfoScribe™ system allows for data collection, analysis and archiving with various input/output devices.

Background

Advanced Air Force systems have become increasingly dependent on more affordable materials and processing. For example, current research in the development of new semiconductor materials will require years of experimental processing and analysis. Cost is driven by unique combinations of material compounds which are grown and controlled at the atomic-scale. Conventional systems for precision processing of these materials often rely on a single controller and software code. If modifications or additions are necessary, the software code typically must be changed - a complex, time-consuming, labor intensive effort that inhibits system operation. If one software module fails, the entire system often fails. If failure occurs during material growth, the material must be scrapped. The InfoScribe™ system avoids these problems. This modular system includes a datalogger, the centralized data source for all InfoScribe™ modules and archived data files. Independent modules can be added or exchanged depending on the particular application. No modifications are necessary in the primary datalogger code when changes are made in the system setup. InfoScribe™ modules encompass data acquisition, process control, post-process data analysis and conversion of data to multiple external analysis formats. For materials processing systems, modules include InfoSupervisor™ program supervision (an ion gauge, shutter actuator interface for material deposition control), proportional-integral-derivative temperature acquisition and control, *In-situ* Messenger™ for customized manual control, LabView™ interface and a flux compensator module for *in situ* control optimization. InfoScribe™ system modules interact through a Macintosh-based language called Inter-Application Communication. The InfoScribe™ system has been applied to molecular beam epitaxy systems.

Air Force Association Award for Materials Research Leadership

Payoff

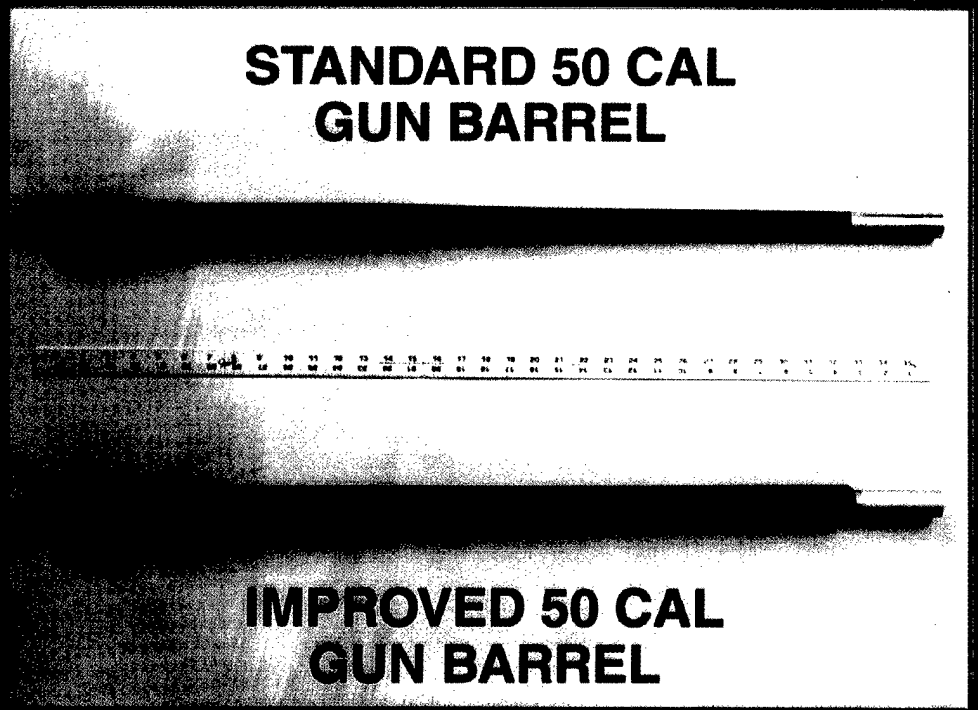
Dr. James C. Malas' role in the development of new metal forging process design and control methods has led to the transfer of this new processing approach to the industrial community. It is applicable to a wide range of metallic materials and forming processes, and is expected to reduce manufacturing costs by 25 percent. He is a role model in showcasing Wright Laboratory's research and development accomplishments and enhances the "good neighbor" image of the Air Force through his involvement in the local educational community.

Accomplishment

Dr. James C. Malas of Wright Laboratory's Materials Directorate received the Award for Outstanding Civilian Manager for 1995 from the Air Force Association's (AFA) Wright Memorial Chapter in Dayton OH. He was recognized for his achievements in the development of new metal forging process design and control methods for high-performance turbine engine components and his participation and contributions to the industrial and local educational communities.

Background

The AFA is an independent organization committed to broad citizen support of the Air Force mission. As part of this commitment, individual AFA chapters annually recognize outstanding achievements by Air Force military and civilian personnel for significant contributions to their professions and areas that extend beyond their immediate professional responsibilities. Dr. Malas led a research team in developing new process design and control methods for near netshape forming of titanium aluminide alloys. While these alloys offer great potential as materials for turbine engine components, forge processing of titanium aluminide often results in deformation fracture, cracking and loss of microstructure control. Dr. Malas's group developed a new processing approach for efficiently and effectively forging titanium aluminide alloys into near netshape components, while achieving the desired material microstructures and properties. This new approach is applicable to a wide range of metallic materials and forming processes, and is expected to achieve savings of up to 25 percent in manufacturing costs. Dr. Malas was instrumental in transferring this technical advance to the industrial community by organizing technical sessions, presenting technical papers at conferences, leading a series of technology orientation trips to metal forming companies and establishing a special Forging Consortium involving thirteen companies. The award also recognized his support of the Growth in Education through a Mathematical Mentorship Alliance (which offers Dayton-area math and science teachers unique experiences through summertime internships within Wright Laboratory) and his participation for the past five years as a mentor for teacher-interns and other mentors, providing meaningful laboratory research experiences.


STANDARD 50 CAL
GUN BARREL
IMPROVED 50 CAL
GUN BARREL

Improved 0.50 Caliber Gun Barrel for Special Operations Forces Helicopters

Payoff

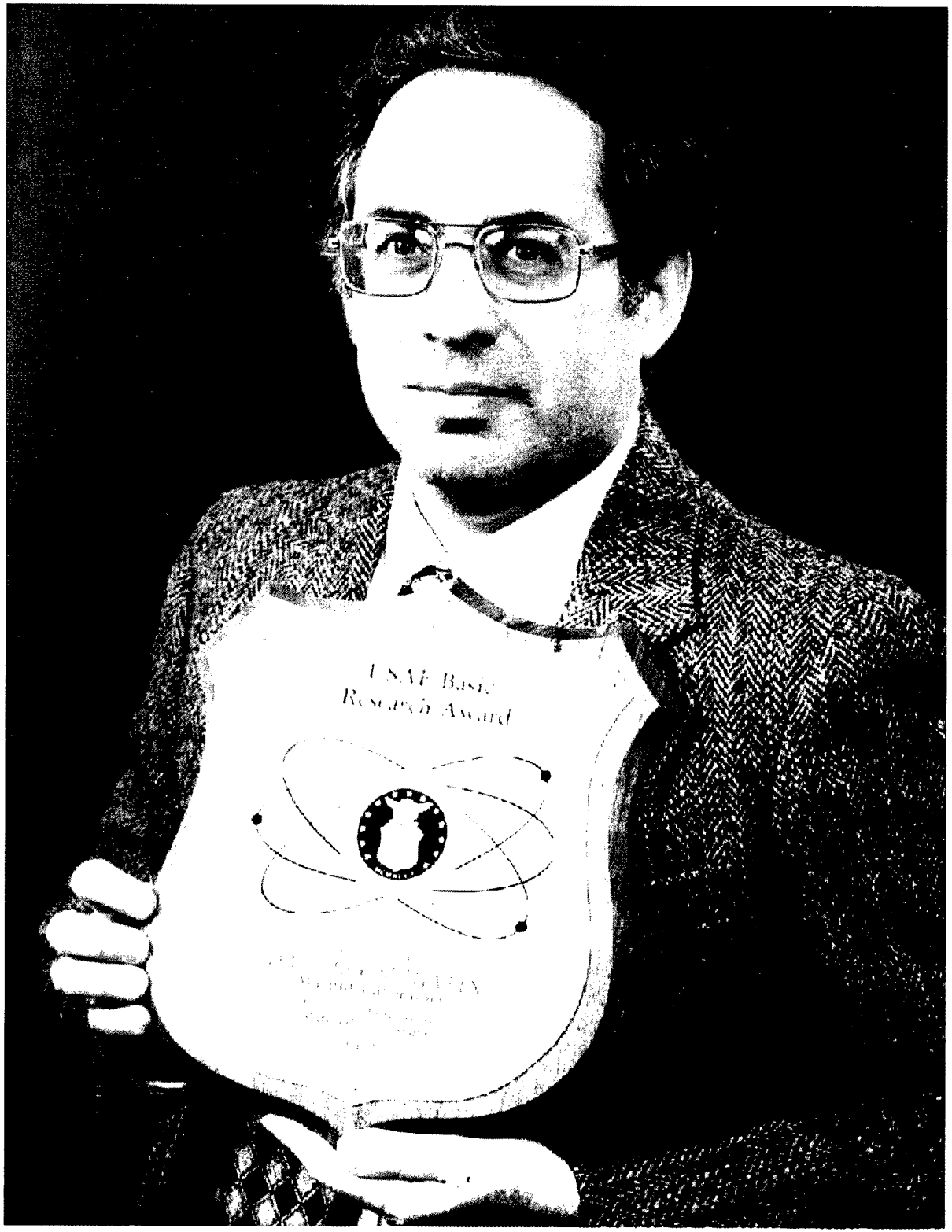
The Air Force Special Operations Command will realize a dramatic improvement in aircrew and aircraft safety along with improved performance of the GAU-18 gun used on the MH-53J and MH-60G helicopters through the use of an improved 0.50 caliber gun barrel. This new gun barrel will provide accurate gunfire and double the usable barrel life during the more severe operational firing conditions encountered by Special Operations Forces (SOF) helicopters.

Accomplishment

Armament Directorate engineers developed an improved gun barrel for the GAU-18 gun that provides a dramatic improvement in barrel life and reduced projectile dispersion. The new 0.50 caliber gun barrel design uses state-of-the-art materials, an improved stellite liner interface and additional material in critical areas of the barrel to eliminate the potential of structural failure. It is capable of firing 5000 rounds of ammunition under very harsh firing conditions followed by a continuous fireout burst of 800 rounds without catastrophic failure as expected with the standard barrel.

Background

In November 1993, Armament Directorate personnel were briefed by Headquarters Air Force Special Operations Command (HQ AFSOC) officials from Hurlburt Field on the deficiencies of the GAU-18 gun barrel used on the MH-53J and MH-60G helicopters. Designed during World War II, the present barrel does not have the structural integrity needed to provide accurate gunfire or reasonable barrel life during the more severe operational firing conditions encountered by SOF helicopters. These deficiencies have caused barrel material failure resulting in projectiles exiting through the side of the barrel and impacting the helicopter. Following review of the standard gun barrel's design, the Armament Directorate recommended a less expensive barrel design using state-of-the-art materials and manufacturing technology, an improved barrel liner interface, and thicker walls at critical areas of the barrel. The new barrel was fabricated and tested in-house by the Directorate's Munitions Division with excellent results. The testing followed several operational GAU-18 firing schedules specified by HQ AFSOC. Based on the positive results of these in-house tests, a production contract was initiated by the Warner Robins Air Logistics Center.


USAF Basic
Research Award

Air Force Basic Research Award for GAMMA Titanium Aluminide Alloys Development

Payoff

The contributions of Dr. S. Lee Semiatin have spurred extensive worldwide research into gamma titanium aluminide alloys and are leading to substantial performance improvements in these and other difficult-to-work materials for many Air Force systems applications. His achievements help to enhance Wright Laboratory's reputation as a world leader in materials development and highlight the Laboratory's efforts to support Air Force operational requirements.

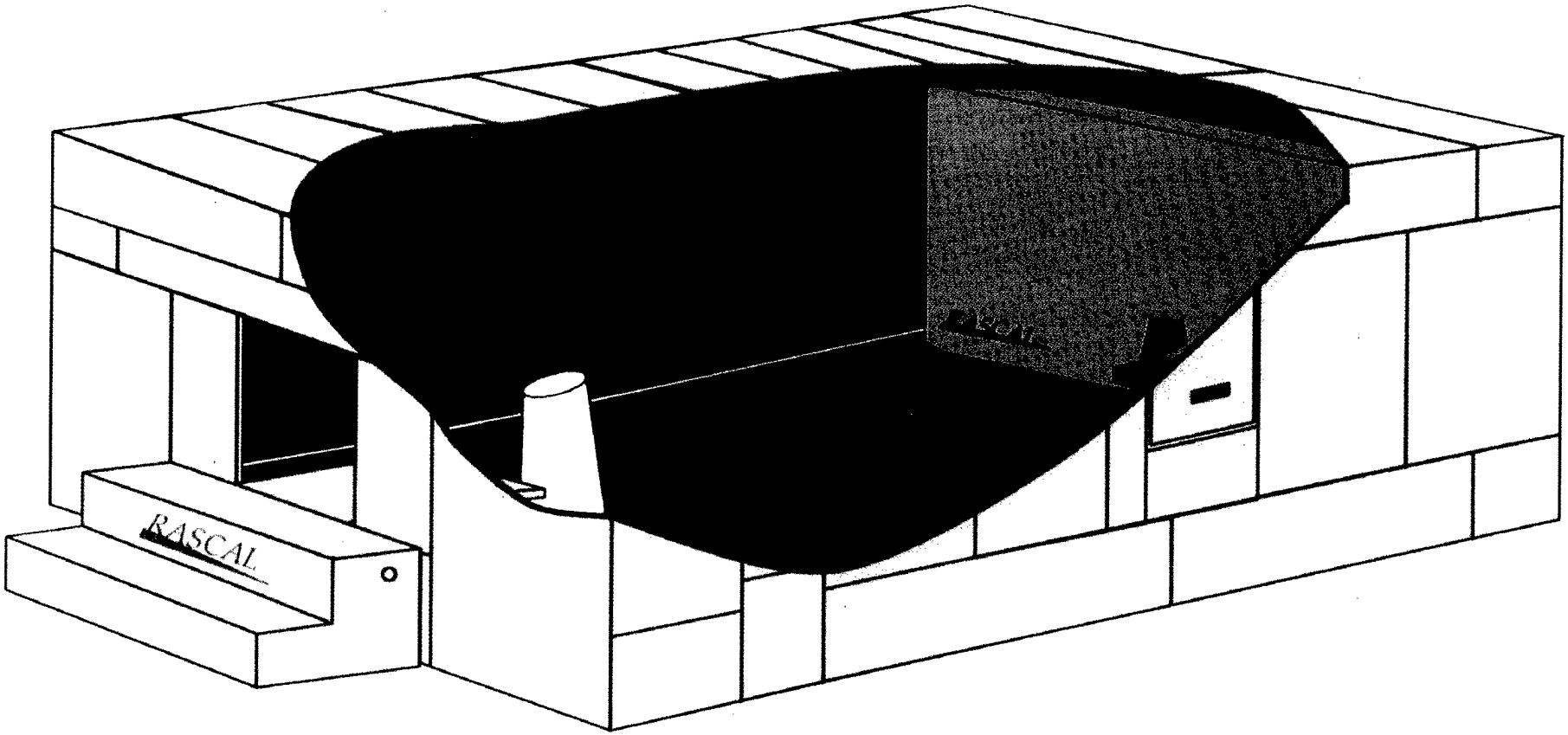
Accomplishment

Dr. S. Lee Semiatin of the Materials Directorate was presented the 1995 Air Force Basic Research Award by Dr. Edward A. Feigenbaum, Air Force Chief Scientist, for contributions to the understanding and development of processing methods for gamma titanium aluminide alloys. This award is presented annually to acknowledge the scientific achievements of Air Force in-house basic research activities and to recognize those scientists who make outstanding contributions in a specific technical area.

Background

While Gamma titanium aluminide alloys offer potential to improve the performance of jet engine components, early parts made of these alloys performed poorly. An understanding of microstructure development and control for these materials was necessary to realize their full potential. Dr. Semiatin led a broad interdisciplinary program to investigate four key problem areas in the wrought processing of gamma titanium aluminide alloys. The first area dealt with ingot cracking problems. Large cast ingots of gamma titanium aluminide alloys are very brittle and often crack, resulting in reduced product yield. Dr. Semiatin developed an advanced fracture model to analyze the casting process and permit selection of processing conditions to obtain sound, defect-free materials suitable for forging, extrusion, rolling and sheet forming. The second area involved nonuniformities in castings. Solidification of gamma titanium aluminide alloys invariably leads to undesirable nonuniform microstructures which persist during subsequent operations. Dr. Semiatin developed a model to explain this phenomenon and the special heat treatments necessary to eliminate nonuniformities. In the third area, Dr. Semiatin developed an explanation for the mechanisms controlling the evolution of uniform, fine microstructures and fracture occurrence in the gamma titanium aluminide alloys during forging and extrusion. The fourth area addressed sheet rolling and superplastic sheet forming. Here, Dr. Semiatin developed a fundamental understanding of microstructure development and fracture for these processes as well. This led to the development of processes using simple encapsulating techniques to allow conventional rolling equipment for sheet production.

Radiation And Scattering Compact Antenna Laboratory



The Radiation and Scattering Compact Antenna Laboratory (RASCAL)

Payoff

RASCAL supports the radio frequency (RF) antenna aperture technology development vital to the Air Force mission by providing timely, accurate, low cost measured data. The low cost RF measurement capability allows for the evaluation of next generation, multi-function aperatures supporting electronic warfare, radar, communication and navigation.

Accomplishment

The Avionics Directorate's Electronic Warfare Division designed and developed a novel RF "mini-compact" range referred to as RASCAL. Precise measured radiation and scattering data is used to: validate in-house computational electromagnetic codes, evaluate prototype hardware and verify hardware from exploratory and advanced developmental efforts.

Background

The role of antennas as the "eyes and ears" of the sensor suites continues to make RF antenna technology development vital to the Air Force mission. Airborne antenna apertures of the future will be broadband, low radar cross section (RCS) and multi-functional. In recent years, an effort has been made to use sophisticated computational methods to design these apertures; however, there remains a myriad of complex configurations that cannot be studied analytically. Moreover, theoretical results generated by numerical methods still require extensive experimental validation. RASCAL was established to provide this precision measurement capability for validation and evaluation. Antenna aperture measurements (both radiation and radar cross section) typically mandate a large physical distance. To simulate a uniform plane wave in a limited amount of space, RASCAL is equipped with a precision manufactured, rolled-edge reflector which collimates the impinging spherical wave from an offset feed, resulting in a uniform plane wave. The reflector is housed in a completely reconfigurable aluminum enclosure (presently 24 feet long, 12 feet wide, and 9 feet high) that allows RASCAL to be placed in nearly any area. To reduce the measurement noise floor (i.e., provide a larger measurement dynamic range), unwanted reflections from the enclosing structure are eliminated by lining the aluminum walls with a revolutionary curved pyramid and curved wedge absorber. The shape and composition of this absorber yield superior performance compared to conventional absorbers of larger physical size. A further reduction in the measurement noise floor is obtained through the use of a unique tri-fold entry door that not only seals RASCAL during measurements, but also serves as a cantilever that folds into RASCAL to provide access to the test antenna without disruption of the area around the test antenna.

Air Force Materials Researchers Help Develop Revolutionary Bridge Repair Technology

Payoff

A repair and rehabilitation system, that uses carbon fiber reinforced polymer composite to improve stress and load capacity, offers a practical yet revolutionary way to repair the thousands of aging concrete bridges across the United States. This system could prove suitable for protecting a wide range of military and commercial buildings, roads and runways from the ravages of weather and time, as well as earthquakes, aftershocks, hurricanes and bomb blasts.

Accomplishment

The Materials Directorate, working jointly with Lockwood, Jones and Beals, Inc., of Cincinnati OH and the Engineer's Office of Butler County OH, developed a system for the repair and rehabilitation of aging concrete highway bridges. Their system uses an advanced carbon fiber reinforced polymer (CFRP) composite which improves stress and load capacity by as much as 65 percent.

Background

Today's increasing road traffic puts a heavy strain on concrete bridges built to handle the loads of decades ago. Since bridge failures can be catastrophic, structural safety is a major concern. Also of importance is the time required to repair or replace worn-out bridges, as well as, the inconvenience of road closings during repairs. The CFRP, also known as graphite epoxy, was developed by the Air Force Materials Laboratory during the 1960s for use in orbiting satellites and Air Force weapon systems such as fighters, bombers and missiles. This lightweight, yet strong, corrosion resistant CFRP material can be engineered into large structures capable of handling heavy loads. In laboratory stress and load tests, actual unreinforced concrete beams (8 feet long by 6 1/2 inches thick by 18 inches wide) failed at a load of 23,000 pounds. When a one-pound sheet of CFRP, 0.014 inch thick, was applied to the underside of a similar beam, the CFRP-reinforced beam withstood a load of 38,000 pounds. The conventional method of bolting the material in place during adhesive cure was scrapped, since uniform mechanical pressure could not be assured from side to side and end to end. To achieve uniform pressure, as well as an increase in pressure, a unique vacuum bag assembly was developed and applied completely over the CFRP during adhesive cure. Use of the vacuum bag resulted in tougher, more durable CFRP seals capable of withstanding winter-related freeze-thaw cycles, spring-related floods, mildew and rot, summer heat, and the dryer days of autumn. CFRP reinforcement is being tested on two beams of a bridge in Butler County OH. One beam will be in service for one year and the other for five years, prior to removal for performance comparison with laboratory test data. The Directorate was assisted by personnel in Wright Laboratory's Flight Dynamics Directorate and the Ohio Department of Transportation, who collaborated on the project.

Quality Pathfinder Program Solves Soldering Problems

Payoff

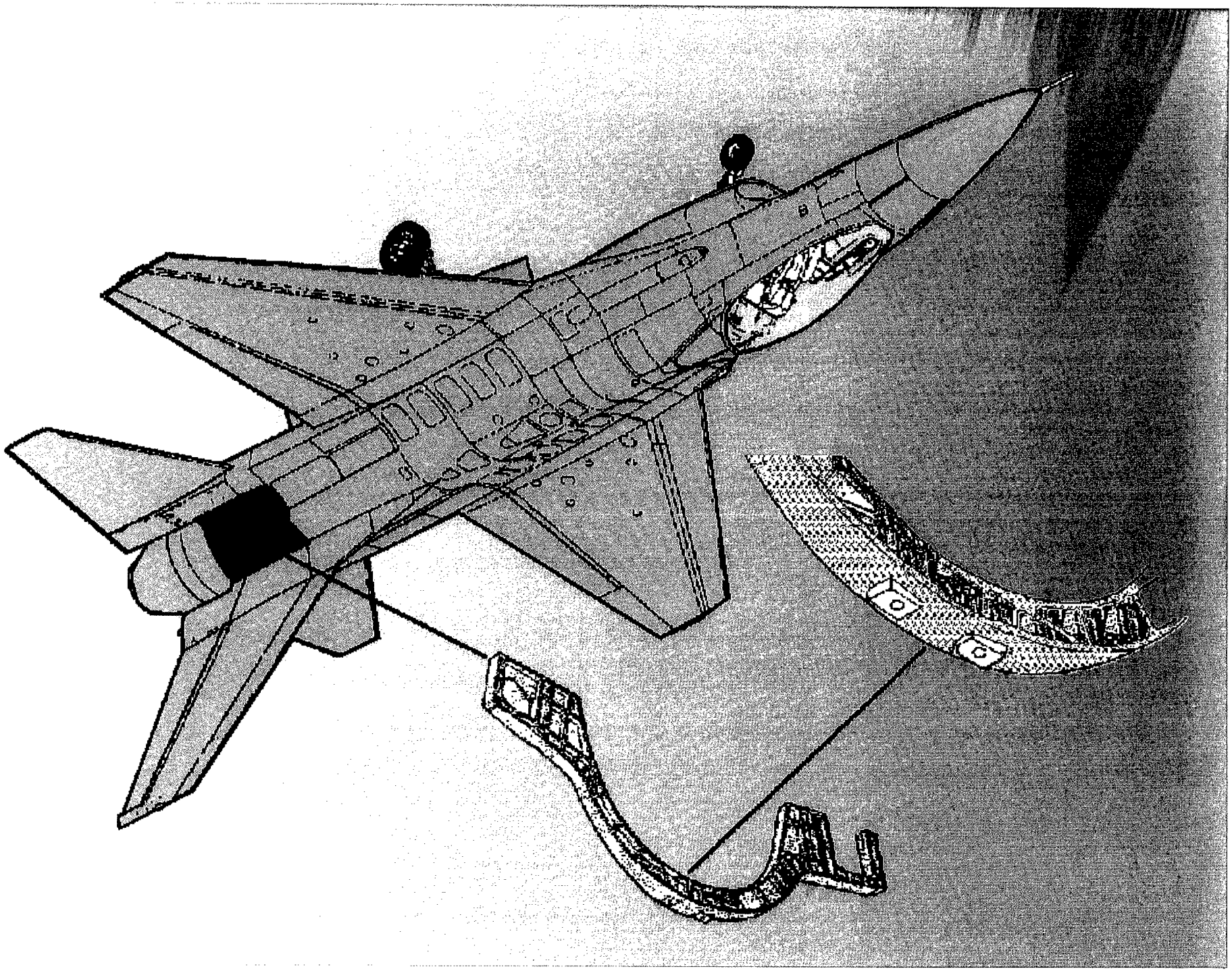
Results obtained from this Manufacturing Technology Directorate Quality Pathfinder program have impacted the way industry uses solder in its manufacturing processes. By putting in place process control techniques, implementing specific quality tolerances and installing new equipment, this program will save the Air Force $250,000 per year in production of F-15 radar systems. In addition, the statistical process control and design of experimental methods used to identify problems and improve the soldering process can be transitioned to improve other manufacturing processes.

Accomplishment

Under a program sponsored by Wright Laboratory's Manufacturing Technology Directorate, Hughes Aircraft Co., El Segundo, CA, used an integrated product team development approach to identify and optimize key soldering process characteristics. This Quality Pathfinder Program called "Integrated Approach to Achieve a Robust Surface Mount Technology Solder Process," improved the quality and reduced the cost of each module used on F-15 radar systems by 14 percent, resulting in savings to the Air Force of $250,000 a year.

Background

The cost savings achieved were obtained by examining current baseline manufacturing processes and then implementing tolerances within specific limits throughout the soldering system, creating a "six-sigma"-capable process. One improvement was use of a test board system to verify solder temperature and validate that the system was operating with the required precision. Guidelines were developed that aided in determining the proper lead to pad ratio, pad size and neckdown from pads to conductors. Solder paste was added to the process to improve the adhesion between assemblies and joints. Tooling dies with problems in the coining process were identified, which led to retooling and solder quality improvements. Additionally, new and upgraded equipment was installed. The result of these quality initiatives was that the practice of 100 percent inspection could be eliminated, creating a reduction of 13 percent in rework, materials, inspection labor and associated overhead costs while providing a better quality product. The results of this program were so successful that Hughes officials anticipate using the same statistical process control methods for their F-18 radar board assemblies and multi-chip module facility. These enhanced manufacturing processes can be implemented by any industry using hot-bar soldering processes. The statistical process control and design of experimental methods used to identify problems and improve techniques can also be transitioned to improve other manufacturing processes.



TEST SUPPORT HELPS SOLVE FATIGUE CRACKING PROBLEM

Payoff

Extensive testing conducted by the Materials Directorate provided critical fatigue crack growth data that was required for decision making on a new material for bulkhead replacements for aging F-16 aircraft. Replacing cracked bulkheads with aluminum-lithium alloy 2097 will increase F-16 service life, and reduce maintenance frequency and cost. Alloy 2097 bulkheads have been selected as the preferred spare by Ogden Air Logistics Center (OO-ALC) for the entire F-16 fleet.

Accomplishment

The Materials Directorate, working with Lockheed-Martin Tactical Aircraft Systems of Fort Worth TX, conducted extensive fatigue crack growth testing, in support of OO-ALC, which verified material performance capabilities for aluminum-lithium alloy 2097. Test results indicated that fatigue crack growth rates for alloy 2097 are significantly slower than the aluminum alloy 2124 currently used in the tail section of the F-16 aircraft.

Background

As the fleet of F-16 aircraft ages, critical components that are subjected to widespread fatigue damage must be replaced. One such component is the aluminum alloy 2124 bulkhead in the section where the vertical tail is attached. This particular bulkhead, which helps to support the vertical tail, is experiencing fatigue crack growth that has reduced its service life from the projected 8,000 hours before replacement to approximately 2,000 hours. This reduction in service life would increase the number (from one) of required bulkhead replacements during the life of the aircraft, resulting in increased labor and material life cycle costs. Lockheed-Martin and OO-ALC teamed to develop alloy 2097, a lithium-containing aluminum alloy having excellent damage tolerance properties. This alloy has a lower lithium content than earlier generation alloys, thereby greatly reducing thick plate property deficiencies. Tests were conducted under constant amplitude loading, in high humidity, and at various stress ratios to evaluate and analyze fatigue crack growth behavior under simulated conditions. Besides increasing bulkhead service life (3 to 5 times longer), an additional benefit of using alloy 2097 is a 5 percent reduction in weight. This material is a candidate for application to other weapon systems where improved damage tolerance and longer service life is needed.

Test Methodology Validates Coated Transparency Service Life

Payoff

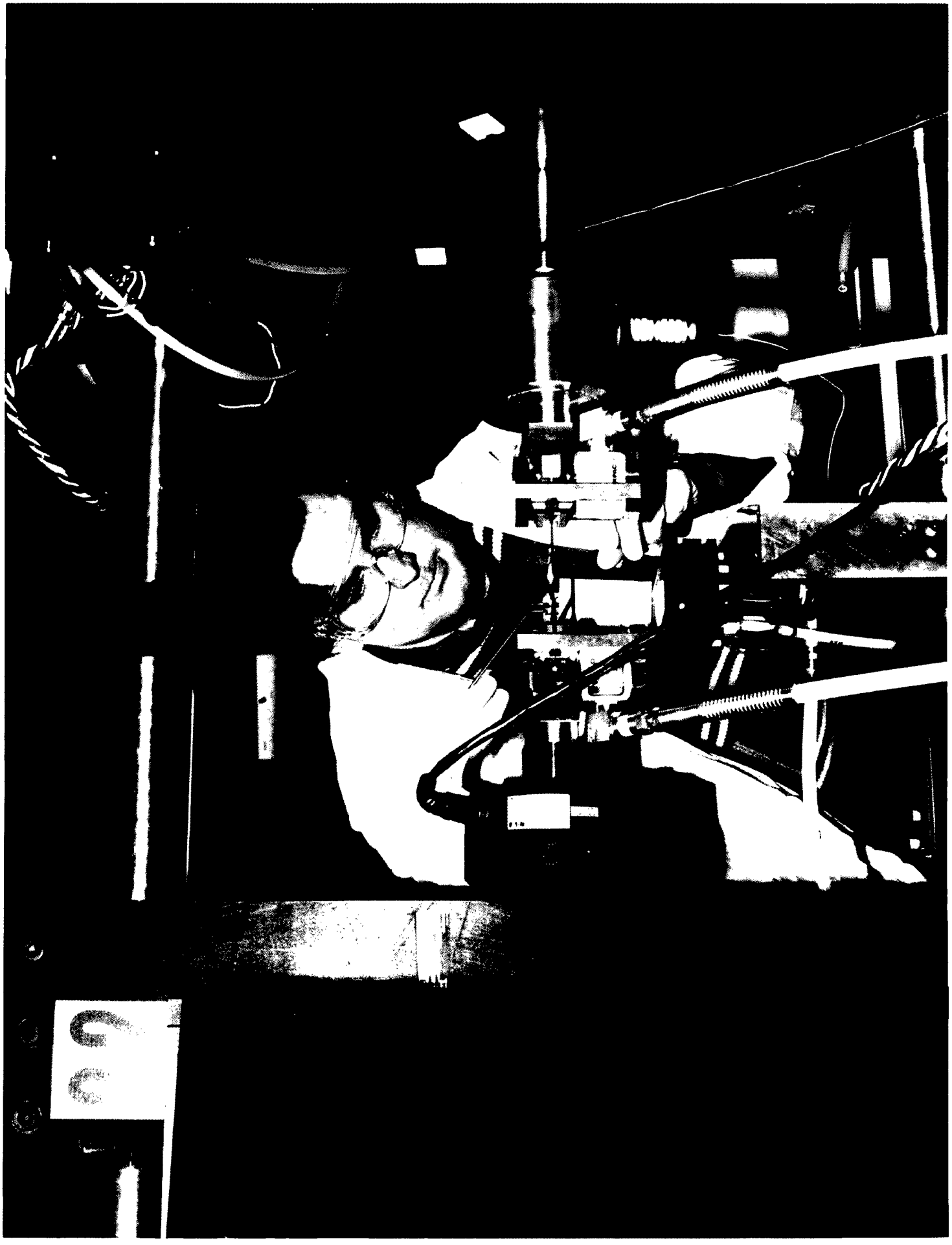
The test methodology developed for aircraft transparency systems will reduce the risk associated with the insertion of coated transparencies into the fleet without the benefit of knowing their expected service life. It has been applied by the Army to select coating systems for its Super Cobra and OH-58D (Kiowa Warrior) helicopters and is being used to evaluate coatings for the F-15, F-16 and F-18 canopies.

Accomplishment

Under a program sponsored by the Flight Dynamics Directorate's Vehicle Equipment Division, a test methodology was developed for aircraft transparency systems that duplicates the operational flight environment (i.e. rain, sand, ice, chemicals, ultra-violet rays, stress and heat) and permits the accelerated evaluation of transparency environment durability, with or without applied coatings. An evaluation criteria based on the test methodology was also developed that transparency developers can include in their specifications to procure coating systems that meet mission requirements.

Background

The Mission Integrated Transparency System (MITS) Advanced Canopy Coating Program focused on increasing the service life of transparency systems. The initial objective of this program was to identify and demonstrate coatings which potentially have a four year service life. The current nominal service life of uncoated transparency systems is two years. The second objective was to develop a test methodology to validate the service life. The initial step in the overall technical approach was to conduct baseline subscale coupon tests of candidate coatings. This was followed by additional subscale tests for the coating systems that showed promise on samples of complex curvature. A total of 18 (hard and soft) coatings were subjected to accelerated weathering through a combination of ultraviolet light, heat and condensation to generate data and validate a test for predicting service life. Combined effects testing was done using weathering and other tests that best simulate the environment which can cause abrasion and cracking of transparency systems.



Materials Scientist Receives Award for Titanium Metal Matrix Composite Development

Payoff

Mr. Paul R. Smith's role in the development of titanium-aluminide matrix composite material is helping to achieve the goal of doubling the performance of gas turbine engines. His accomplishments in titanium metal matrix composite materials development highlight Wright Laboratory's efforts to develop aerospace materials for advanced turbine engines.

Accomplishment

A research scientist from the Materials Directorate received the annual Air Force Materiel Command's Science and Technology Achievement Award for spearheading the development of a new class of titanium metal matrix composite materials. Mr. Paul R. Smith's research produced an orthorhombic-based, titanium aluminide matrix composite (O TMC) that is less dense than the high density, nickel-based superalloys currently used in turbine engine compressors, yet comparable in strength.

Background

The joint DoD, NASA and industry Integrated High Performance Turbine Engine Technology (IHPTET) Program is committed to delivering high performance, affordable gas turbine engines with twice the propulsion capability of today's engines just after the turn of the century. Advanced material developments that reduce component weight without compromising performance, and improve engine efficiency through higher-temperature operation are critical to the achievement of IHPTET objectives. One enabling IHPTET matrix requirement is a titanium metal matrix composite insert in the latter stages of the compressor. As a material of choice for this insert, O TMC material offers a potential weight savings of up to 50 percent and is capable of operation in the temperature range of 1,100° to 1,400° F—up to 200°F higher than current systems. This combination of a strong, less dense material and an increased operating temperature limit permits compressor redesign for greater efficiency. A government, industry and academia team led by Mr. Smith is assessing the capabilities and limitations of O TMC materials in all development and performance areas. O TMC material is also being considered for use in single-stage-to-orbit space vehicles.

Self-Directed Control (SDC) Technology Improves Quality of Superconducting Materials for Passive Radar Systems

Payoff

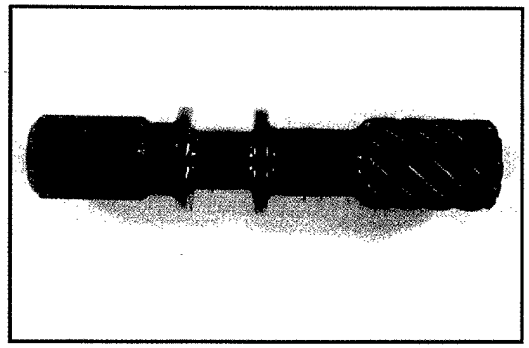
Using the self-directed control technology to produce high temperature, thin film superconducting materials will enable "exotic" materials processing techniques that can help further improve the range and "vision" of microwave radar systems while making the materials easier and cheaper to produce. Near term SDC technology will more than double the yield of usable thin film superconductor material and will enable the production of films tailored to specific radar specifications.

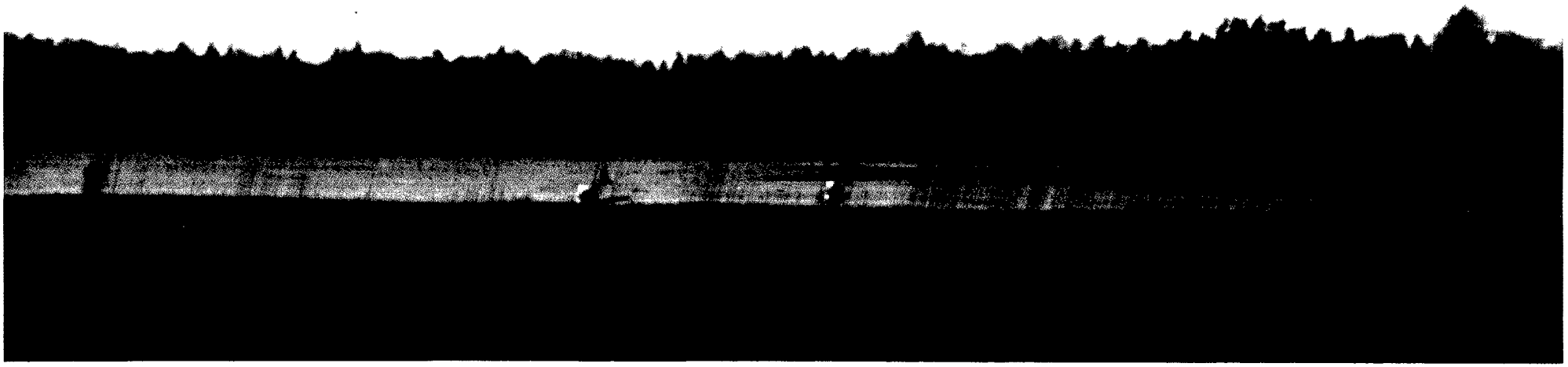
Accomplishment

Materials Directorate researchers discovered a new multi-faceted phenomena associated with incident laser pulse energy and superconducting film microstructure that has led to the generation of high temperature, superconducting (HTS) thin film materials. This discovery involved improvements to the pulsed laser deposition (PLD) process used to deposit a thin coating of material onto the surface of an object.

Background

The high cost of developing sophisticated radar and defensive countermeasure systems presents a clear opportunity for near term research breakthroughs. Researchers in the Materials Directorate developed an advanced processing technology, referred to as SDC, for PLD, a process originally developed to produce solid lubricants and wear-resistant coatings. Using SDC to process a new material has never been achieved before via any process. In PLD, an ultraviolet laser pulse is fired in rapid succession (2 to 20 pulses per second) impinging on a yttrium barium copper oxide target surface, ejecting a plume of material which is deposited as a film on a heated (+1400°F) substrate. Using the SDC technology, laser process parameters are continuously measured and automatically adjusted to assure film quality and consistency. Key process factors, such as chamber background gas pressure, laser beam energy and substrate temperature are all autonomously stabilized to make the process more reliable and repeatable. In terms of more affordable HTS thin films, background gas pressure variance has been reduced from 20 percent to less than 1 percent, and the laser beam energy variance has been reduced from 20 percent to less than 7 percent. As a result, deposited HTS films are of superior quality, i.e., the films are superconducting below -297°F with estimated surface resistances near 0.3 milliohms at -321°F and 10 Gigahertz (GHz) (10^{10} cycles per second). With full implementation of the SDC, routine PLD production of large area (4 inch diameter) superior quality films should be possible.





Quick Reaction Keeps F-15 Aircraft Material Improvement Program on Track

Payoff

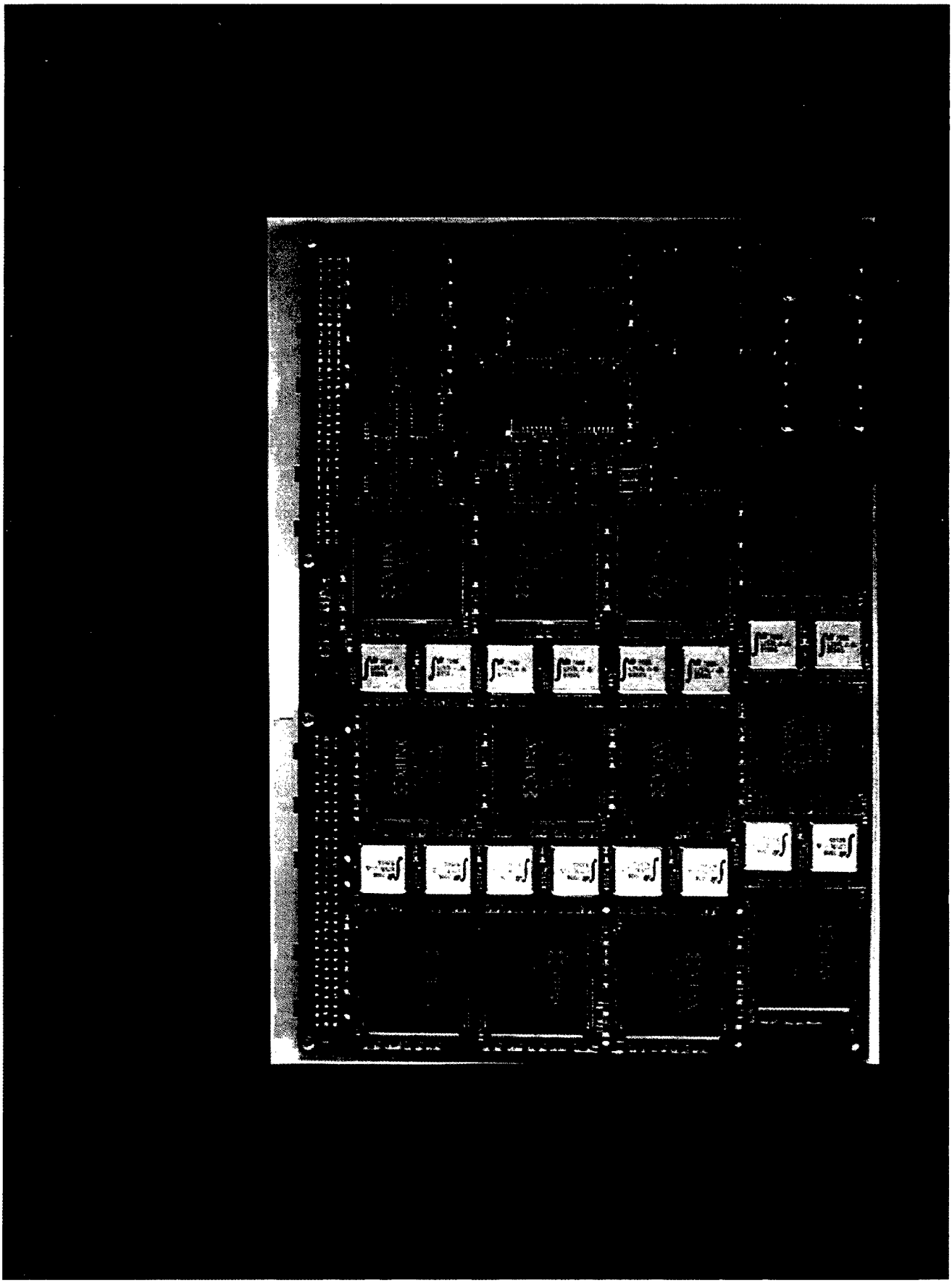
Quick reaction by a team of engineers from the Materials Directorate provided rudder actuator position feedback shaft performance data that helped an F-15 material improvement program go forward with minimum delay. Their analysis provided a cost avoidance of $150,000 while contributing to increased aircraft safety and reliability.

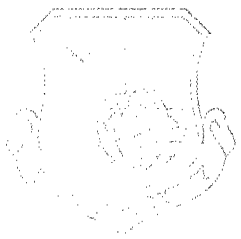
Accomplishment

In 6 weeks, engineers from the Materials Directorate completed tests and analysis of an F-15 rudder actuator position feedback shaft for the F-15 System Program Office. Their quick response provided shaft performance data that put a material improvement program in place 85 percent faster than anticipated.

Background

To enable the F-15 Eagle aircraft to perform its role as an air superiority fighter, its flight control systems must work flawlessly to maintain high maneuverability at speeds in excess of Mach 2.5. When the fleet of F-15 Eagle aircraft began experiencing repeated occurrences of rudder actuator centering guide failures, several in-flight incidents occurred. To solve this problem, the rudder actuator centering guide locking mechanism is being redesigned by McDonnell Douglas Aerospace of St. Louis MO to strengthen the locking mechanism. Before the replacement guide locking device could be manufactured and installed, testing was necessary to confirm the new design's torque resistance limits. McDonnell Douglas estimated it would cost $150,000 and take nine months to acquire the necessary test equipment to provide the required shaft performance data. The Systems Support Division at the Materials Directorate offered to do the testing using equipment already in place — an offer quickly accepted by McDonnell Douglas and the F-15 System Program Office. Feedback shafts were tested to determine torsional yield strength with and without an axial load, both at room temperature and at 275 degrees Fahrenheit. The test data provided information on the levels of torque that the centering guide would have to withstand. Test conclusions indicated that axial load had virtually no effect on the torsional yield strength of the feedback shaft and that an elevated temperature produced only a five percent reduction in torsional yield strength. These results were used by McDonnell Douglas and its subcontractor, to develop improvements to the centering guide locking device design.





Configurable-Hardware Algorithm Mappable Preprocessor (CHAMP) Lays Groundwork for Next Generation of Preprocessing

Payoff

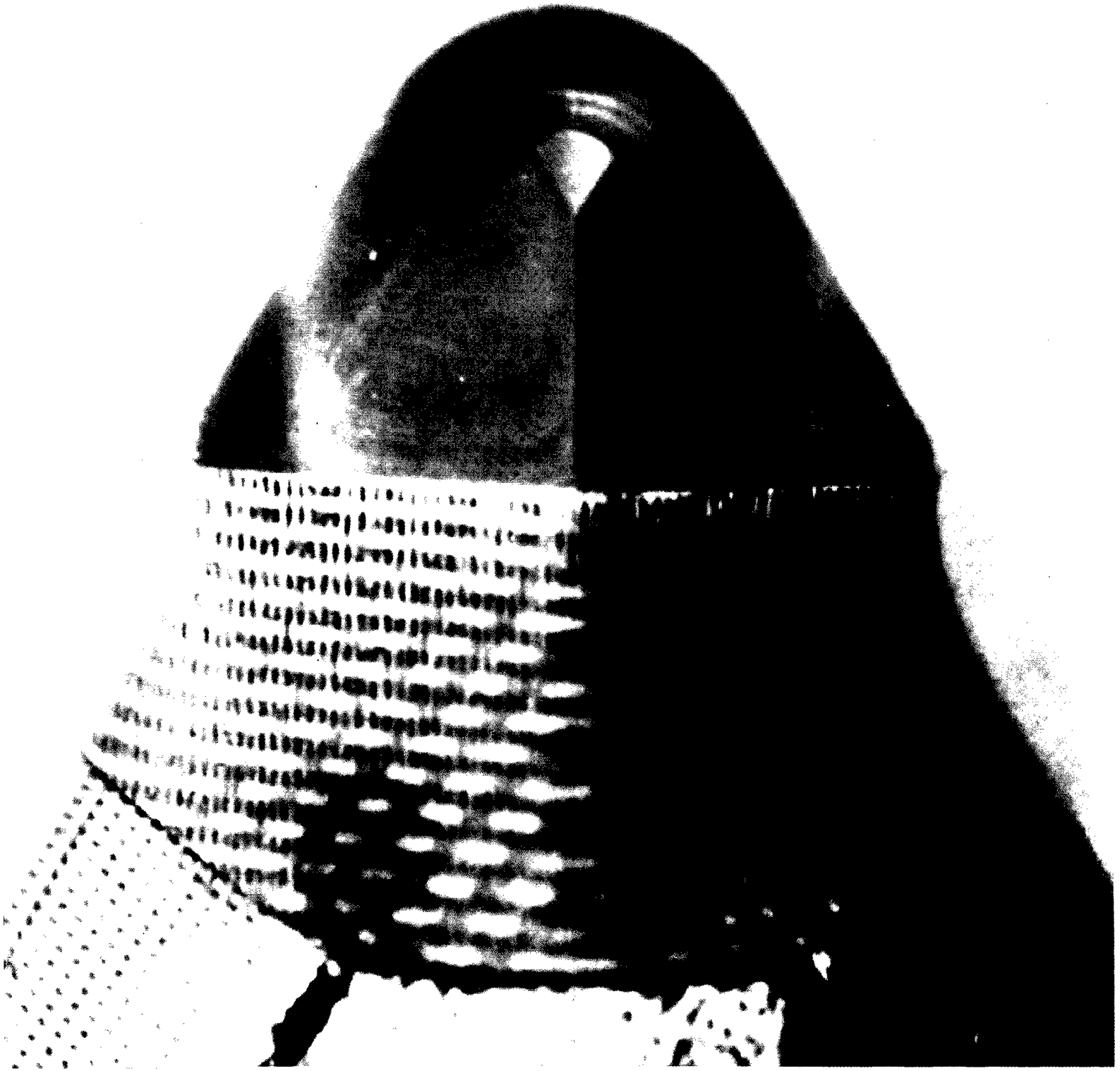
The application of CHAMP technology will provide a significant reduction in life cycle costs for radar, electronic warfare and communication/navigation/identification avionics systems. Leveraging CHAMP based technology to replace a variety of radios with one reprogrammable multi-band, multi-mode radio is expected to significantly shorten the time required to achieve fielded operational communications capability and reduce life cycle support costs.

Accomplishment

Under the CHAMP Program sponsored by the Avionics Directorate, Sanders (a Lockheed Martin Company) developed a new configurable preprocessing technology which provides an alternative to the traditional preprocessing solutions. CHAMP's Random Access Memory based field programmable gate arrays (FPGAs) can be reconfigured as many times as the main memory in a personal computer. One trade-off study result showed that CHAMP outperformed a state-of-the-art reprogrammable preprocessor in the implementation of an infrared search and track algorithm by 27 to 1 (image pixel processing).

Background

The reconfigurable processing arrays were configured through the CHAMP Program to solve very compute intensive preprocessing algorithms. The CHAMP Program objective was to combine the best attributes of Application Specific Integrated Circuits (high performance and small implementation size) and Digital Signal Processors (reprogramability) to develop a third affordable preprocessing solution. The resulting design process for the CHAMP technology involved the development of a library of functional building blocks called Firm Macro's. The Firm Macro concept was the key to the successful development of CHAMP. Under the CHAMP Program, three different infrared algorithms were mapped onto the CHAMP board. When these algorithms implementations were compared to similar implementations for new Digital Signal Processors, the CHAMP based preprocessing provided an advantage in terms of performance, implementation size and, for two of the three implementations, hardware cost. Both the CHAMP design process and the CHAMP preprocessing architecture have been adopted by Sanders for use on several government sponsored programs.



Internally-Cooled Missile Nosetip Withstands Frictional Heat at Hypersonic Velocities

Payoff

The internally-cooled nosetip technology would allow interceptor missiles to operate within the hypersonic speed regime (>4 km/sec) to interdict and destroy enemy tactical and strategic ballistic missiles during their boost phase. An internally-cooled nosetip is being considered for the Army's Atmospheric Interceptor Technology and USAF Boost Phase Interceptor Programs.

Accomplishment

Researchers at Wright Laboratory's Materials Directorate and Thermal Technologies, Inc. (T2I) of Winchester CA, developed an internally-cooled nosetip capable of withstanding high frictional heating levels generated during hypersonic atmospheric flight. The nosetip was fabricated from annealed copper, chosen for its excellent conduction of heat, and is internally cooled with circulating water.

Background

Operation Desert Storm demonstrated that a far more preferable defense against enemy missiles is to destroy them before they can leave enemy territory. This calls for high speed weapon systems capable of dealing with the large quantities of frictional heat generated during hypersonic atmospheric flight. In this speed regime the most intense concentration of heat occurs at the forward nosetip. The extreme frictional heat produces sharply elevated temperatures causing a passive, or uncooled thermal protection nosetip to undergo excessive recession and shape change. This can result in excessive background noise in the interceptor optical seeker system with degradation of target acquisition and tracking, or even loss of target kill. With technical support provided by the Materials Directorate, T2I evaluated materials for an Air Force guided reentry vehicle system concept during tests at the NASA Ames Interaction Heating Facility. This investigation centered on the leading edges of airfoils with a swept angle greater than 60° that must contend with high temperatures generated by velocities up to 7 km/sec and reentry times of 20 minutes or more. Carbon-carbon and graphite, the conventional passive nosetip materials, were found unsuitable due to excessive ablation and shape change. An internally-cooled nosetip was developed capable of withstanding the high frictional heating rates. The nosetips functioned well during the leading edge testing, maintaining their physical integrity without any deformation. Even though temperatures in the hottest region rose to about 1700°F, they remained well below the copper melting temperature of 1980°F. This technology has been transitioned to the Army's Atmospheric Interceptor Technology Program. This program is responsible for the development, integration and demonstration of high performance, lightweight interceptor technology for DoD application, including the USAF Boost Phase Interceptor Program.

VORTEX MODELING ENHANCES C-17 PARATROOP OPERATIONS

Payoff

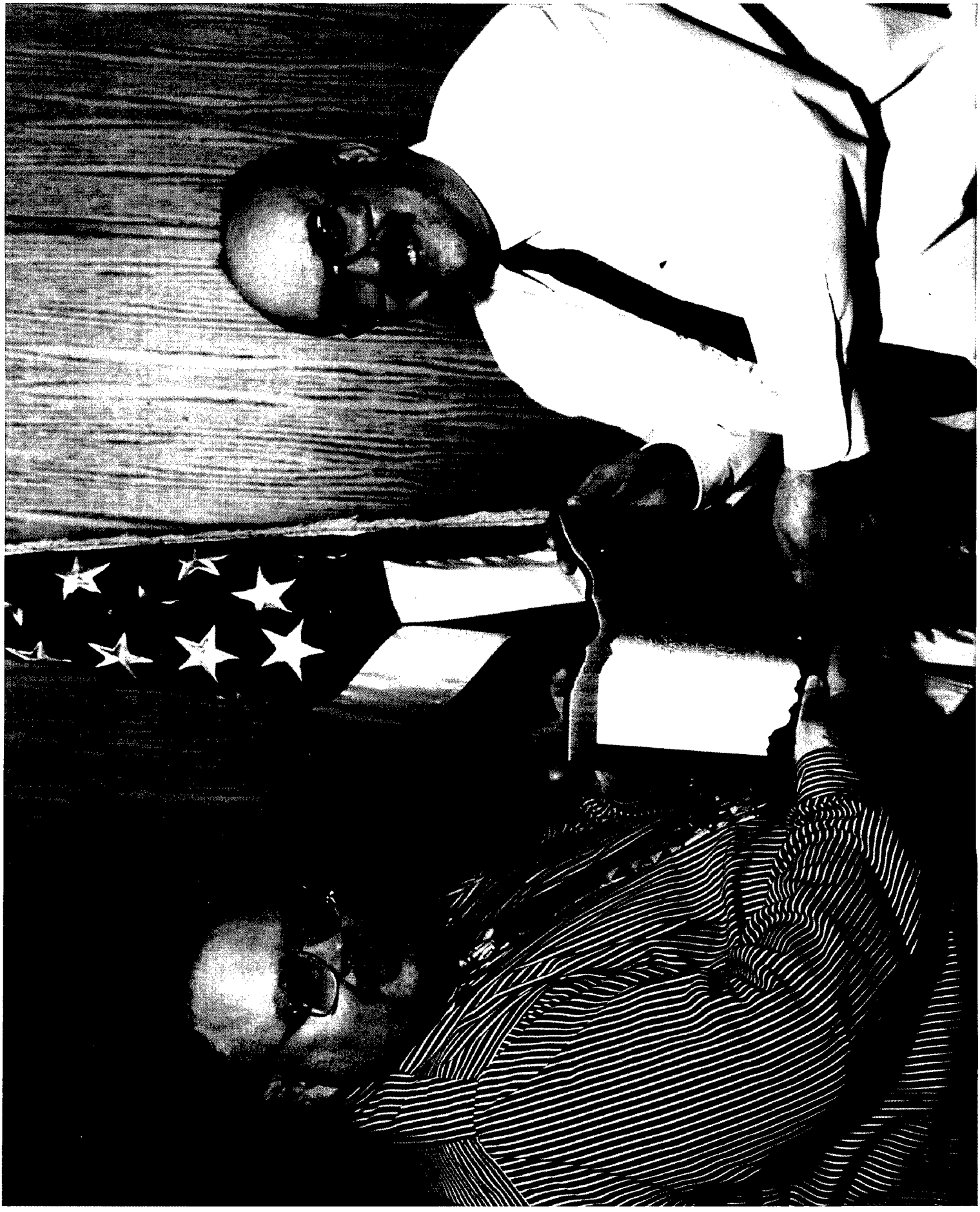
Using vortex modeling to identify the position and strength of the wake vortices of all transport aircraft in a formation will increase the safety for United States Air Force operations and improve air drop accuracy. The computer model developed by the Flight Dynamics Directorate has been used to support C-17 and C-5 airdrop studies and examine air refueling formations using the KC-135 and KC-10 aircraft.

Accomplishment

Under a program sponsored by the Air Mobility Command, the Flight Dynamics Directorate's Flight Control Division developed a computer model that enabled Army paratroopers, during a demonstration on 27 June 1995 at Fort Bragg NC, to safely exit C-17 aircraft flying in formation. By identifying the location and strength of wake vortices behind each aircraft, this model defined the suitable formation geometry for six C-17 aircraft that enabled the paratroopers to avoid potential hazards from wake vortex encounters.

Background

One of the hazards of paratroop operations is falling through the wake vortices generated by an aircraft ahead in the formation. Current jet transports generate vortices that are ten times stronger than those produced by aircraft used for mass airdrops in World War II. These vortices may cause temporary collapse of the paratrooper's parachute. Defining a suitable airdrop formation geometry requires knowledge of the position and strength of the wake vortices of all aircraft in the formation. The position of the vortices was calculated by the Flight Control Division's computer model using theoretical equations, while the strength of the vortices was based on empirical data obtained from 1970's commercial transports' flow fields. The Flight Control Division used similar data obtained in 1988 by the National Oceanic and Atmospheric Administration on the C-141 and C-5 to gain confidence in its application to military transports. A total of 585 mannequins and live personnel were airdropped to test C-17 formations developed with the model. Further wake vortex characterization tests are planned to refine the model.



HAZARDOUS MATERIALS MANAGEMENT PROGRAM RECEIVES GOVERNOR'S AWARD

Payoff

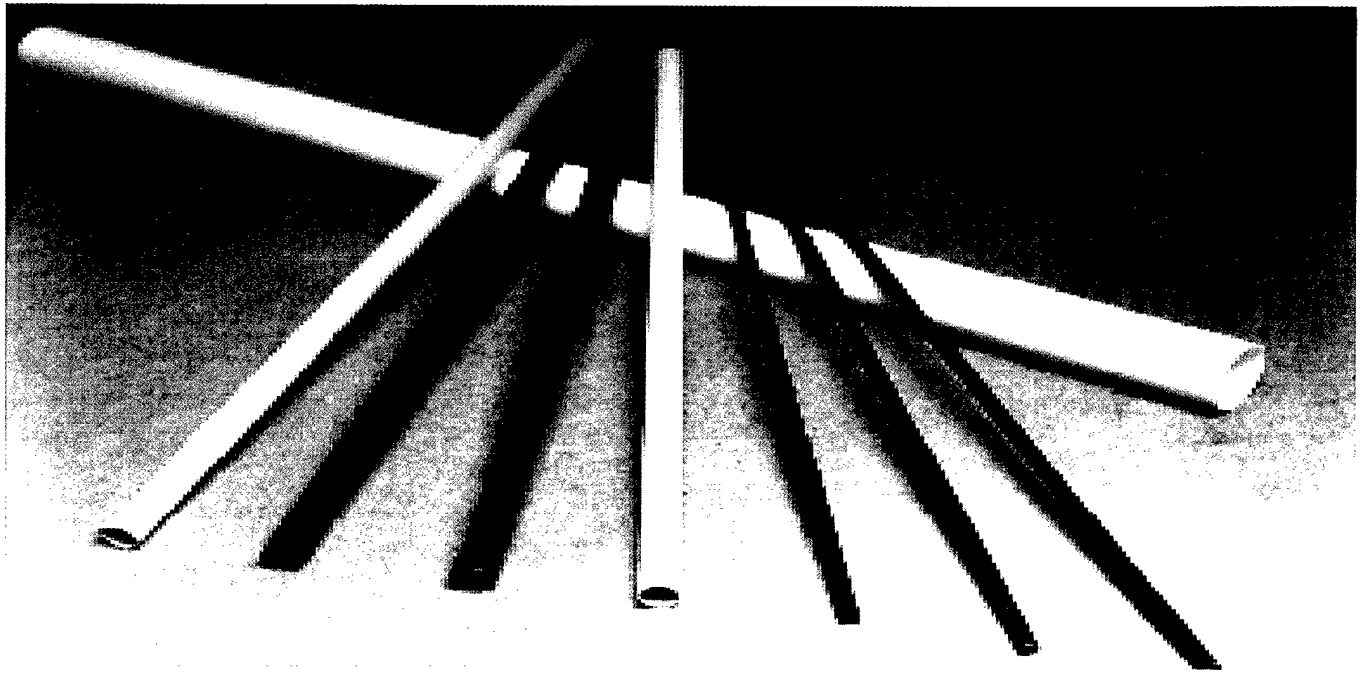
The Integrated Materials Management Program combines hazardous material data from over 300 facilities in Wright Laboratory and other Air Force installations for effective centralized hazardous materials management, waste minimization and pollution prevention efforts. It will reduce material costs and prevent material shortage through more effective control and retrieval.

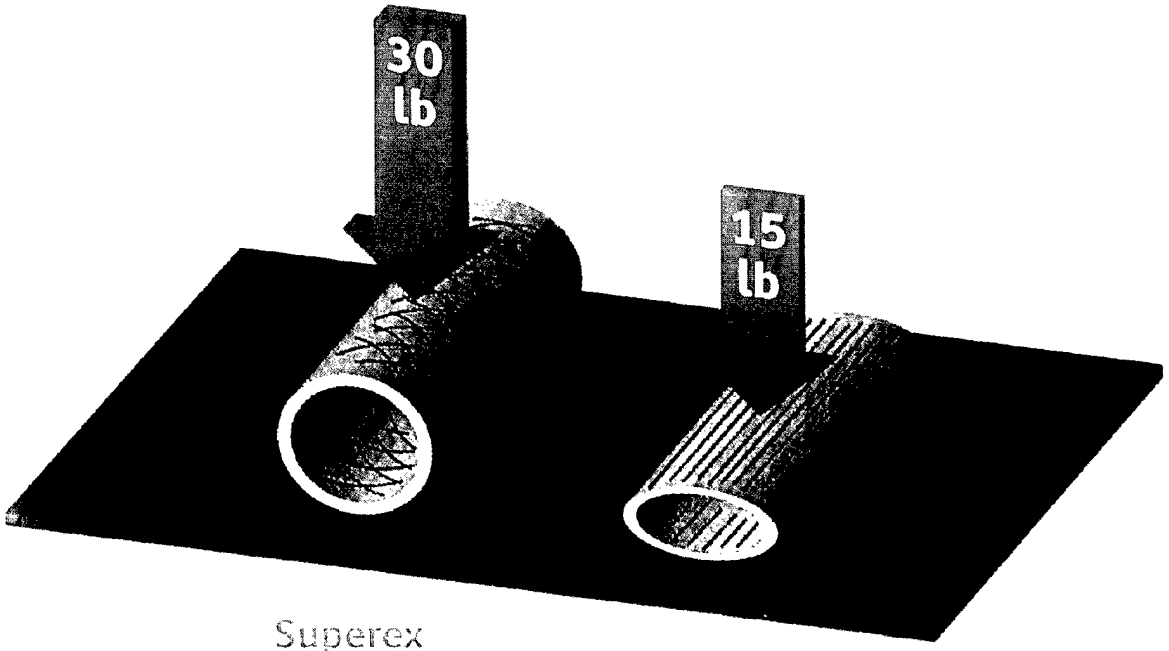
Accomplishment

The Materials Directorate's Integrated Materials Management Office (IMMO) received the 1995 Ohio Governor's Award for Outstanding Achievement in Pollution Prevention for its development and implementation of a comprehensive hazardous materials management and waste pollution prevention program. Criteria for award selection included achievements in reducing waste at the source, recycling or recovering materials, efficiency and innovation, economic benefits and the ability of the program to serve as a model for others.

Background

The Materials Directorate uses more than 15,000 different chemicals in over 50,000 containers in its 150 facilities. This level of activity and complexity necessitates a very aggressive pollution prevention program to assure that health and safety are top priorities, and that environmental issues are correctly managed. In 1990 the Directorate, working with Modern Technologies Corporation of Dayton OH, established the IMMO to develop and implement an ongoing program for hazardous materials management and waste pollution prevention. A computerized system using bar code technology was developed to coordinate the tracking and control of hazardous materials including inventory levels, location changes, usage rates and other critical data. Storage of hazardous chemicals has been consolidated, helping to eliminate duplicate and excess stock. The system has been extended to include facilities across Wright Laboratory and has been selected for implementation at other Air Force installations. Over 50,000 hazardous materials and waste containers have been tracked throughout their complete use life, resulting in the purging of over 15,000 hazardous material containers no longer needed by researchers. More than 400 containers of unknown materials have been identified, classified and eliminated. The IMMO efforts have included replacement chemicals that are less harmful to the environment, such as, isopropyl alcohol instead of methanol for glass cleaning and hexane instead of methylene chloride. Since 1986 the State of Ohio, working through its Environmental Protection Administration, has presented annual Governor's Awards to honor outstanding achievement in pollution prevention. These awards recognize accomplishments of companies, organizations or individuals who have made exceptional efforts to reduce pollution through source reduction or waste recycling.





Superex
Tube

Conventional
Extrusion

NEW TYPE PLASTIC TUBING - R&D 100 AWARD

Payoff

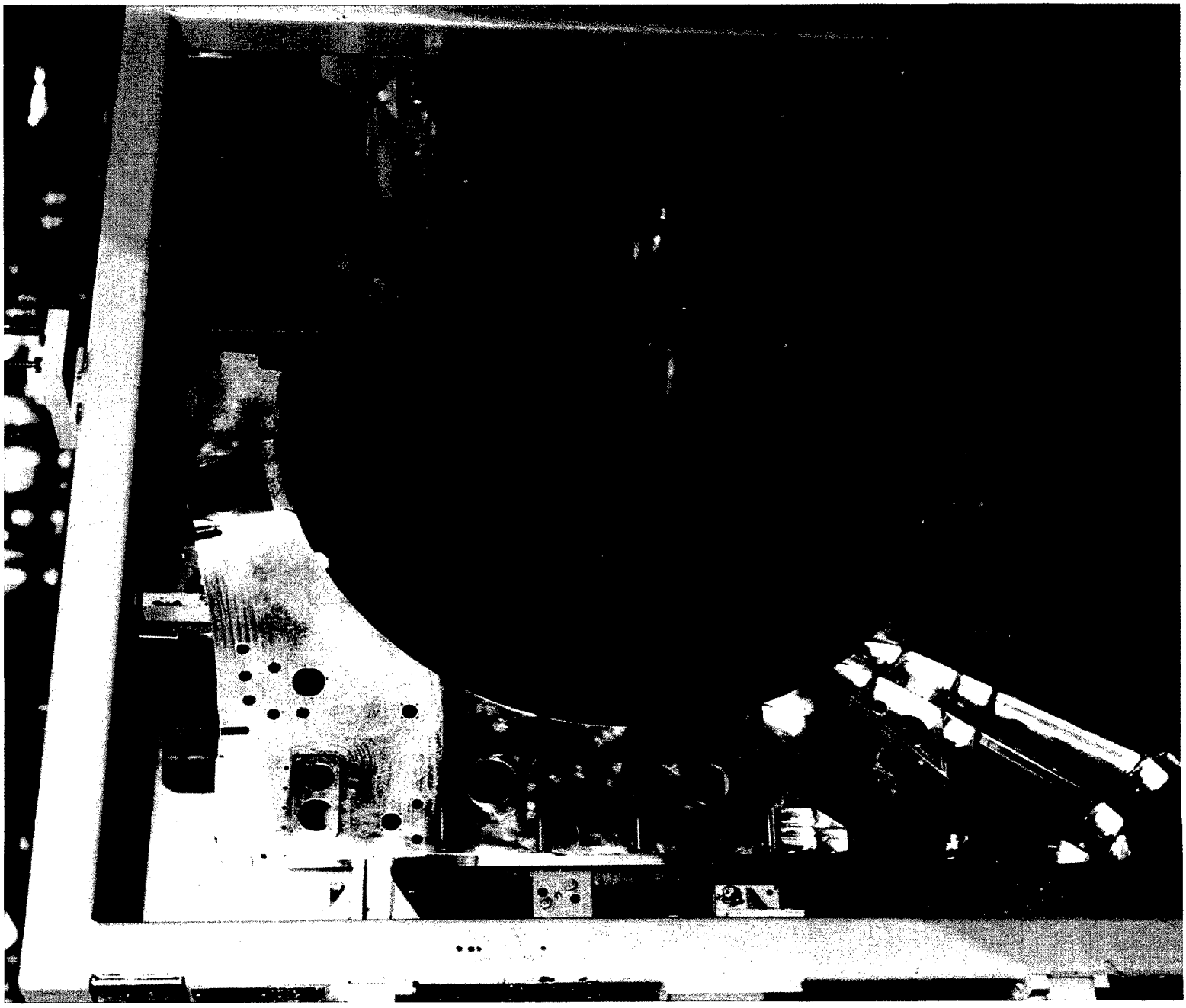
The new rigid plastic tubing, which will lower the cost of building and operating Air Force space-based systems, is another example of technology transfer to the private sector. Identified by R&D Magazine as one of the 100 most technologically significant products of 1995, its first commercial application in endoscopic surgical devices will provide higher performing, lower cost designs. Other potential applications include cryogenic containers and fuel lines, chemical transfer pipes and automotive fuel lines.

Accomplishment

The development of a new type of rigid plastic tubing was recognized by R&D Magazine as one of the 100 most technologically significant products of 1995. The award was given to a team of Foster-Miller, Inc., Ballistic Missile Defense Organization (BMDO), National Aeronautics and Space Administration (NASA) and Materials Directorate personnel. This light weight tubing, extruded from high-performance liquid crystal polymer, has double the crush resistance of today's conventional rigid plastic tubing and costs up to 60 percent less to produce.

Background

Structures and equipment used in space must be lightweight to minimize transport payload requirements, yet strong enough to endure the harsh extraterrestrial environment. Liquid crystal polymers such as polybenzoxazole (PBO) and polybenzothiazole (PBT) are used to produce rigid rod tubing lighter than aluminum, steel, graphite-epoxy or fiberglass-reinforced composites for space-based structures. Conventional thermoplastic extrusion processing of liquid crystal polymers tends to orient polymer molecules parallel to the length of the tubing so that the greatest strength runs lengthwise, with only moderate resistance to crushing the tube flat. With technical support from the Materials Directorate and financial support from BMDO and NASA, scientists at Foster-Miller Inc. of Waltham MA, developed a method to produce tubing with greater stiffness and strength. Their method used advanced die technology to produce tubing with twice the resistance to crushing by simultaneously orienting polymer molecules in two principal stress directions perpendicular to each other, and at an angle to the length of the tubing. Exacting extrusion control permits achievement of tubing with precise cross-sectional net shape, possessing near-zero coefficient of thermal expansion and high stiffness. The tubing is an excellent electrical insulator, has high temperature capability of over 200 degrees Centigrade, and offers good chemical resistance. Properties for individual tubing types can be varied by choosing different grades of polymer and by adjusting the operating parameters of the extrusion equipment. The first commercial application for the tubing is in endoscopic and minimally invasive surgical instruments offering higher performance and lower cost than competing designs.



Virtual Manufacturing (VM) Provides Cost Benefits

Payoff

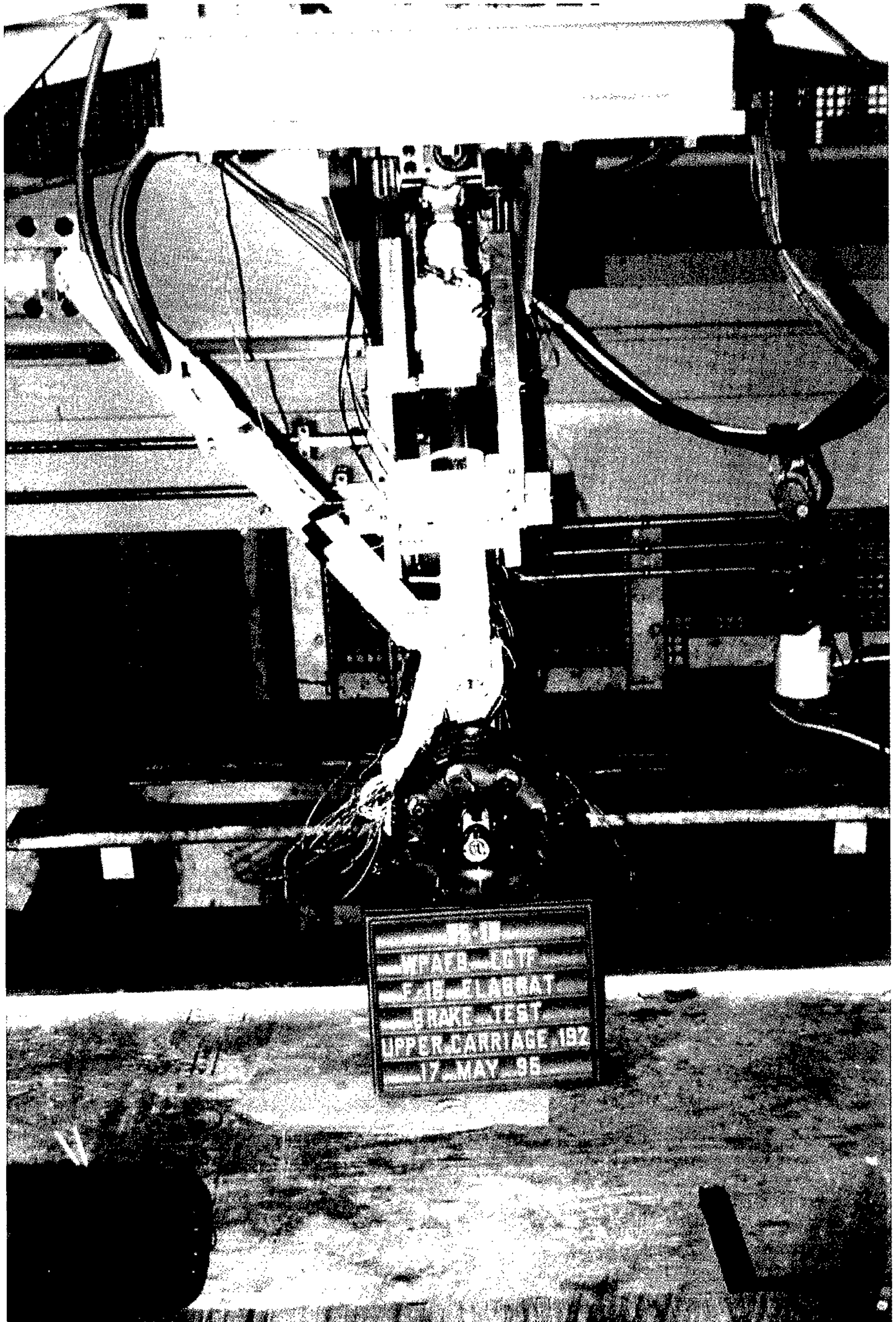
The F-15E airframe structural support (former), shown left, developed under the prototype Joint Advanced Strike Technology (JAST) Fast Track Program, illustrates the capability and practicality of the VM approach. It provides McDonnell Douglas Aerospace with a validated redesign, manufacturing and assembly process for the airframe former scheduled for incorporation in the next F-15E upgrade. The VM approach not only reduces design and manufacturing cycle times, but it can also be used to substantiate projected cost and affordability savings in future aircraft procurements.

Accomplishment

Under a prototype Fast Track Program sponsored by the Manufacturing Technology Directorate in conjunction with the JAST Program Office, McDonnell Douglas Aerospace demonstrated cost benefits of a VM approach in aircraft system design. Prototype VM techniques were applied to the redesign of an F-15E mid-fuselage former (structural support member between bulkheads) resulting in a 33 percent reduction in design release time, 27 percent reduction in design cost, 19 percent reduction in manufacturing cycle time, 20 percent reduction in factory floor space utilization, 24 percent reduction in part count and a 78 percent reduction in fasteners required for assembly.

Background

VM is an integrated, synthetic manufacturing environment employed to enhance all levels of decision control in a manufacturing enterprise. The objective of the prototype JAST VM Fast Track Program was to provide a first-cut practical demonstration of key VM technologies and to quantify the potential benefits in a real-world scenario. A production change to a flight qualified F-15E mid-fuselage airframe former was prompted by a business case analysis and provided an ideal opportunity to compare a well-documented approach with the new VM approach. This new approach integrates available, proven technologies such as feature-based design, finite element analysis, feature-based machining, assembly simulation and manufacturing flow simulation. Using the integrated VM technologies along with existing process and product models, McDonnel Douglas Aerospace evolved a computer representation of the F-15E airframe former and developed a production process that simulated various design and production scenarios. Seven design alternatives of the airframe former were produced using the standard design approach and one using the new VM approach. When the two approaches were compared the prototype VM techniques required less time to design, evaluate and incorporate the airframe former design alternative from a form, fit, function and affordability perspective. A cost/benefit analysis was conducted in order to quantify cost savings during the design and manufacture process.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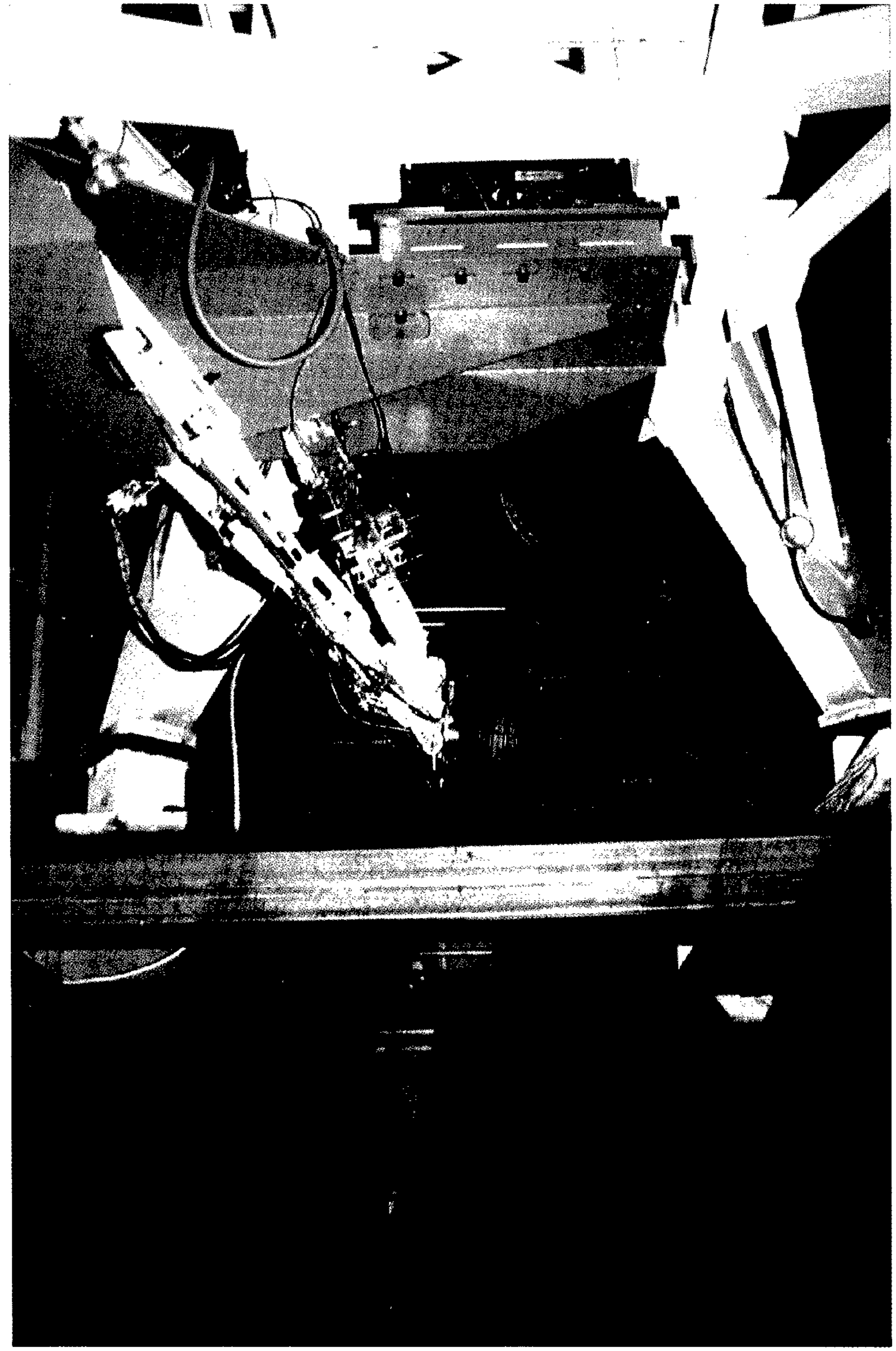
F-15 FLAGBAT
BRAKE TEST
UPPER CARRIAGE 192
17 MAY 95



Electrically Actuated Brake Technology (ELABRAT) System will Eliminate Hydraulic Fluid Fires

Payoff

The successful completion of the ELABRAT Program has established the ELABRAT system as a viable aircraft braking system capable of superior performance relative to the current F-16 system. In addition to the elimination of brake hydraulic fluid fires, its application will result in a significant reduction in brake system maintenance as well as increased tire and brake wear life.

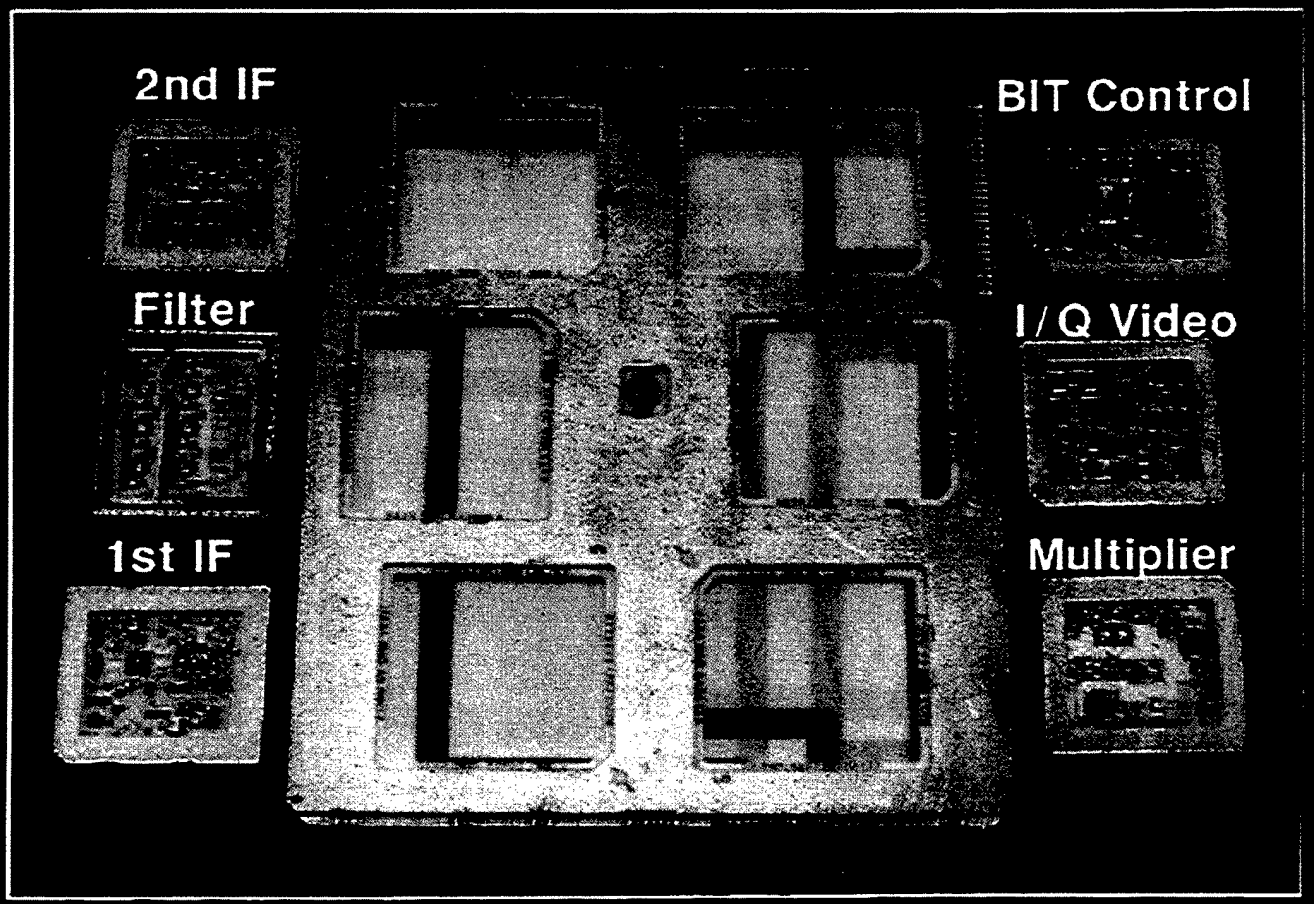
Accomplishment

A team led by the Flight Dynamics Directorate took a major step towards eliminating aircraft brake hydraulic fluid fires. An F-16 aircraft brake/antiskid system utilizing electromechanical actuation with brake torque control was developed by the team and tested. This full scale system demonstrated consistent braking response regardless of brake friction variations due to moisture or contamination. The improved anti-skid system operated at 98 percent efficiency with the electromechanical actuated brake. The electrically actuated brake technology team was selected by the Aviation Week and Space Technology Magazine in January 1996 as a recipient of an Aerospace Laurel Award.

Background

Brake hydraulic fluid fires account for 45 percent of aircraft hydraulic fire incidents and braking systems are a significant contributor to aircraft maintenance. To address these issues, the ELABRAT Program was initiated and a team established to design, fabricate and demonstrate an electric brake system using full scale aircraft hardware. The team of Wright Laboratory, McDonnell Douglas Aerospace, BF Goodrich Wheel and Brake, Crane Hydro-Aire and BF Goodrich Motion Controls developed an integrated design incorporating electromechanical actuation with an advanced anti-skid system using a fiber-optic sensor. A significant feature of this system is the utilization of brake torque control as opposed to conventional brake pressure control. The resulting system provides superior reliability by providing full braking performance with only two of the four actuators working. This system demonstrated the ability to follow a torque command input up to the limits of the tire/dynamometer friction with 50 volts direct current (VDC) input power as well as functioning well at 28 VDC (battery backup voltage). By incorporating brake torque control, pilots will get a consistent braking response regardless of brake friction variations due to moisture or contamination.

LTCC IF Receiver Motherboard and IMA Packages



Advanced Low Temperature Co-Fire Ceramics (LTCC) Makes Radio Frequency Avionics Efficient and Cost Effective

Payoff

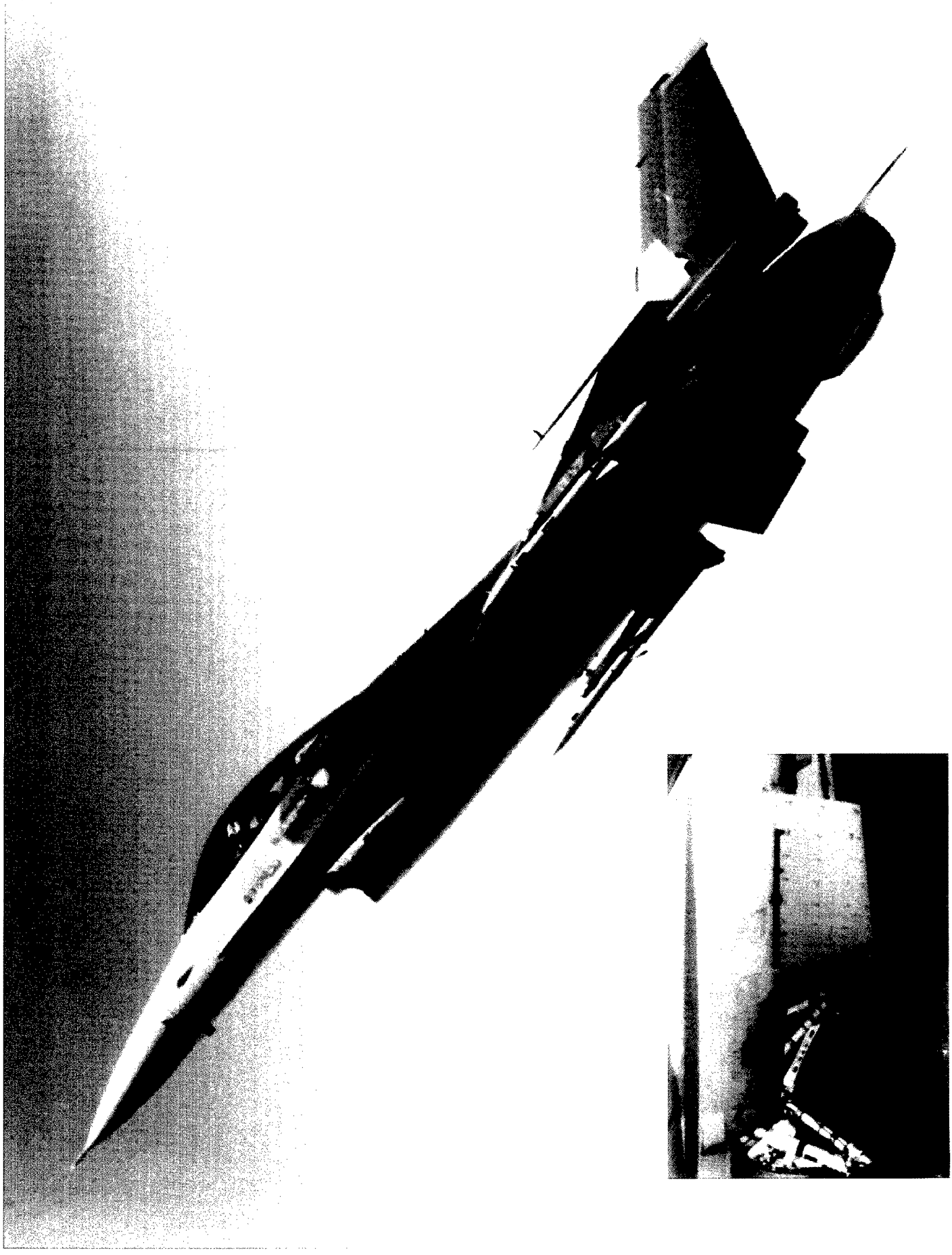
The LTCC material capabilities enable modular design (motherboard and integrated microwave assembly packages) amenable to product manufacturability, ease in development test and verification, field repair and maintenance. The weight and volume efficiency of LTCC makes two-level maintenance for complex radio frequency (RF)/microwave and digital circuits cost effective. The advanced LTCC material system technology was applied in the F-22's high dynamic radar receiver development and was shown to have significant advantages over existing methods of packaging RF high density integrated circuits.

Accomplishment

A program sponsored by the Avionics Directorate's System Avionics Division resulted in the development and demonstration of weight, volume and performance efficient motherboard/ modules for low-power RF avionics receiver hardware. This development focused on improving RF avionics reliability, maintainability and reduction of parts count, weight, volume and life-cycle cost.

Background

Traditional RF avionics receiver hardware is not weight and volume efficient and the complexity of its assembled parts drives the cost of radar electronics. In response to the need for improved RF avionics availability, the development of the LTCC material system technology was addressed under the Advanced Aircraft Avionics Packaging Technology Program initiated by the Avionics Directorate in 1989. The LTCC material system, designed and fabricated for the F-22, densely packaged the analog, digital and RF circuitry into the Intermediate Frequency (IF) receiver module of the aircraft's low-power RF system. The multi-layer 6.4 inch by 5.8 inch LTCC structure enables cost reduction and reliability improvements through the use of buried, dense electrical elements which makes the fabrication process amenable to automated manufacturing. Further evidence of the broad capabilities and benefits of the LTCC technology was demonstrated when it was applied to redesign the functions of the existing IF receiver module of the F-16 APG 68 C/D radar system.



New Aluminum Composite Material Increases Life Expectancy of F-16 Ventral Fins

Payoff

Application of the stiff, durable, discontinuously-reinforced aluminum (DRA) metal matrix alloy will increase the expected life for F-16 ventral fins by more than a factor of two.

Designated as the preferred spare for F-16s, ventral fins mark the first large scale structural application of DRA in a production aircraft.

Accomplishment

The Materials Directorate, working as technical sponsors with the Title III Program Office of the Manufacturing Technology Directorate and DWA Composite Specialties of Chatsworth CA, developed a durable metal matrix composite material with the stiffness of titanium and the weight of ordinary aluminum alloy. Together with the F-16 System Program Office, they identified this discontinuously reinforced aluminum (DRA) metal matrix alloy as a replacement for the material currently used in the F-16 Fighting Falcon aircraft's ventral fins. The DRA, made up of 6092 aluminum alloy reinforced with silicon carbide particulate, improves stiffness by as much as 50 percent and offers more than 17 times the operating life achieved with ordinary aluminum alloy fins.

Background

F-16 Fighting Falcon aircraft are the backbone of the Air Force fighter fleet, being flown by active as well as Reserve and National Guard units. Ventral fins, located under the aft section of the aircraft's fuselage, provide added stability during tight, high-speed turns. When the engine's throttle is sharply reduced during flight, sudden air buildup in front of the engine intake often spills over and subjects the fins to severe buffeting and turbulence. The fins are also subject to side loading forces during turns. These forces result in a tendency for conventional aluminum alloy fins to wobble, fail and tear off in less than 400 hours of flight time compared to their expected lifetime of 3,000 hours. For stiffness-critical components, such as F-16 ventral fins, DRA provides a unique capability as a material with the stiffness of titanium and the weight of ordinary aluminum alloy. DRA fins are projected to last 7000 hours with an associated increase in fin stability. The DRA metal matrix composite's machinability using conventional machining techniques makes it a viable candidate for other stiffness-critical components. The first ship sets of the new ventral fins have been fabricated by Ogden Air Logistics Center at Hill AFB UT, and additional sets have been ordered for National Guard F-16s.

Quick Reaction Support Improves Amphibious Assault Capability

Payoff

The amphibious assault capability of the Navy's Land Craft Air Cushioned (LCAC) vehicle was improved when it was demonstrated that a large caliber weapon, such as the GAU-13 Gatling gun, could be fired from the vehicle to neutralize beach obstacles. Eliminating barriers, including those that could have mines attached to them, will increase the effectiveness and survivability of LCAC vehicles during amphibious beach assaults.

Accomplishment

Quick reaction support provided by the Armament Directorate demonstrated the practicality of firing a large caliber weapon from a Landing Craft Air Cushioned (LCAC) vehicle to neutralize beach obstacles. During feasibility tests, the GAU-13 Gatling gun destroyed a large assortment of mechanical barriers used by some countries to prevent an amphibious beach assault.

Background

The primary mission of the LCAC vehicle is to transport people, weapon systems, equipment and cargo to the shore and over the beach at speeds up to 40 knots. Riding along on a cushion of air, the transition from water to land is easy and trouble free except when the beach is protected or blocked to prevent a landing. In April of 1995, Armament Directorate personnel submitted a proposed program to the LCAC test director at the Naval Surface Warfare Center that outlined the feasibility of equipping the craft with a large caliber weapon, like the GAU-13, to clear a landing path on obstructed beaches. This program, called Direct Fire Neutralization of Beach Obstacles, was completed in 60 work days at a cost of $60,000. The gunpod system, an "off-the-shelf" weapon system that had been slated for destruction, was used to house the GAU-13 to keep the cost at a minimum. The GAU-13 is a newer, lightweight 30mm variant of the GAU-8/A used on the A-10 close air support aircraft. LCAC crews, during Desert Storm, confronted blocked beaches that included concrete tubes, steel tetrahedron shaped devices and even "jersey barriers" (the same kind seen along the interstate highway system). While these are relatively "low tech" devices, they are barriers that can pack quite a punch when mines are attached to them.

Project Wright Connection Provides "Real World" Applications for Teachers

Payoff

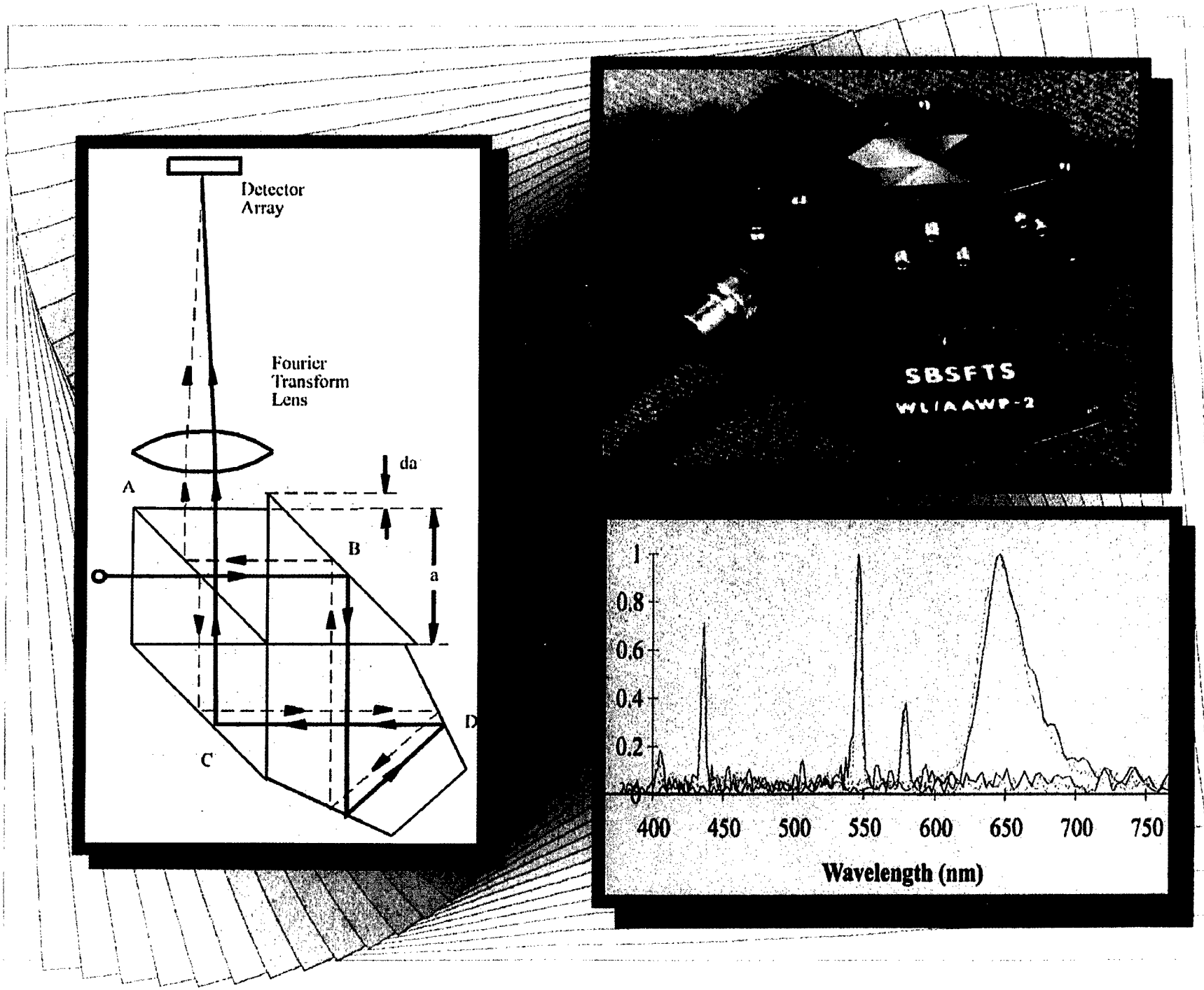
By providing Dayton area math and science teachers with real world experiences, Project Wright Connection inspires new ways for teachers to pass on knowledge to their students. The involvement of Wright-Patterson Air Force Base in the program enhances the "good neighbor" image of the Air Force in the local community.

Accomplishment

The Wright Connection partnership of representatives from Wright Laboratory, The Alliance for Education and Dayton area businesses and schools is helping high school mathematics and science teachers gain on-the-job experience to develop novel teaching aids. The project is sponsored primarily by the National Science Foundation and will cover more than 100 school districts. Site-based internships are provided at Wright-Patterson Air Force Base and businesses in the Dayton surrounding area.

Background

The Alliance for Education piloted Project Growth in Education through a Mathematics Mentorship Alliance (GEMMA) in 1990. The cornerstone of the project was a seven-week-long summer experience for teachers that included one-on-one government or business mentors. Each teacher is assigned projects within the organization that are selected from the mentor's scientific interests. Teachers have done everything from research-level work with a scanning electron microscope in Wright Laboratory's Materials Directorate to making rounds in emergency rooms at Children's Medical Center. During the past five years, 88 mathematics and science teachers from 39 schools in 17 districts benefited from Project GEMMA. With the receipt of a $2 million grant from the National Science Foundation, GEMMA was expanded and is now known as Project Wright Connection. The three year growth will enable program sponsors to increase teachers participation to an average of 100 a year.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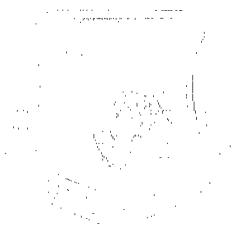

New Compact Sensor System Improves Environmental Pollution Monitoring and Laser Threat Detection

Payoff

The solid-block, stationary Fourier transform spectrometer demonstrates a key enabling technology for rugged, miniature, imaging spectrometers applicable to a wide class of spectroscopic instrumentation. This includes laser warning for detection of laser-aided weapons, pollution detection for environmental monitoring, biomedical instrumentation and industrial process control.

Accomplishment

Scientists at the Avionics Directorate developed a compact, low-cost, monolithic stationary Fourier transform spectrometer for use in detecting laser-aided weapons and environmental pollution. This solid-block spectrometer is interferometrically stable (provides good spectral resolution and long-term stability) in adverse operating environments and is made from off-the-shelf optical components requiring no special fabrication steps.

Background

Lasers used on the modern battlefield are posing an ever growing threat to aircraft and crew. To enhance survivability against laser-guided weapons, sensors are needed with the capability to detect these threats. These sensors must work in a wide-range of hostile environments and detect laser threat parameters, including wavelength, coherence and direction of arrival. The Avionics Directorate supports this effort through a vigorous in-house laser-sensor research program that has produced a variety of hardened interferometric sensor technologies. In an effort to improve laser-warning sensor technology and support the transfer of sensor technology to environmental monitoring, the Directorate participated in a joint Department of Defense, Department of Energy and Environmental Protection Agency Strategic Environmental Research and Development Program. The program's goal was to examine the feasibility of an interferometrically-based sensor to detect hazardous waste. Funding from this program provided the necessary leverage to produce the key components for the spectrometer. With the support of the joint program and the ongoing in-house laser-sensor research program, a miniturized, stationary Fourier transform spectrometer was developed to satisfy the extremely demanding requirements of both applications. This device, capable of delivering 1-2 nanometer resolution with high-optical throughput, consists of low-cost, off-the-shelf optical components permanently cemented into a monolithic glass element. The completed device will be integrated into a Raman-based sensor for the environmental application and undergo laboratory evaluation and field trials at a national environmental test site. The solid-block spectrometer has been patented and designated as an Air Force invention.


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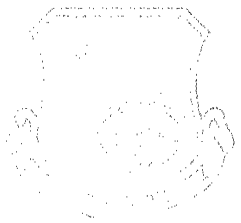


Plastic Optical Device Offers High Efficiency Transmission of Light Waves for Optical Computers

Payoff

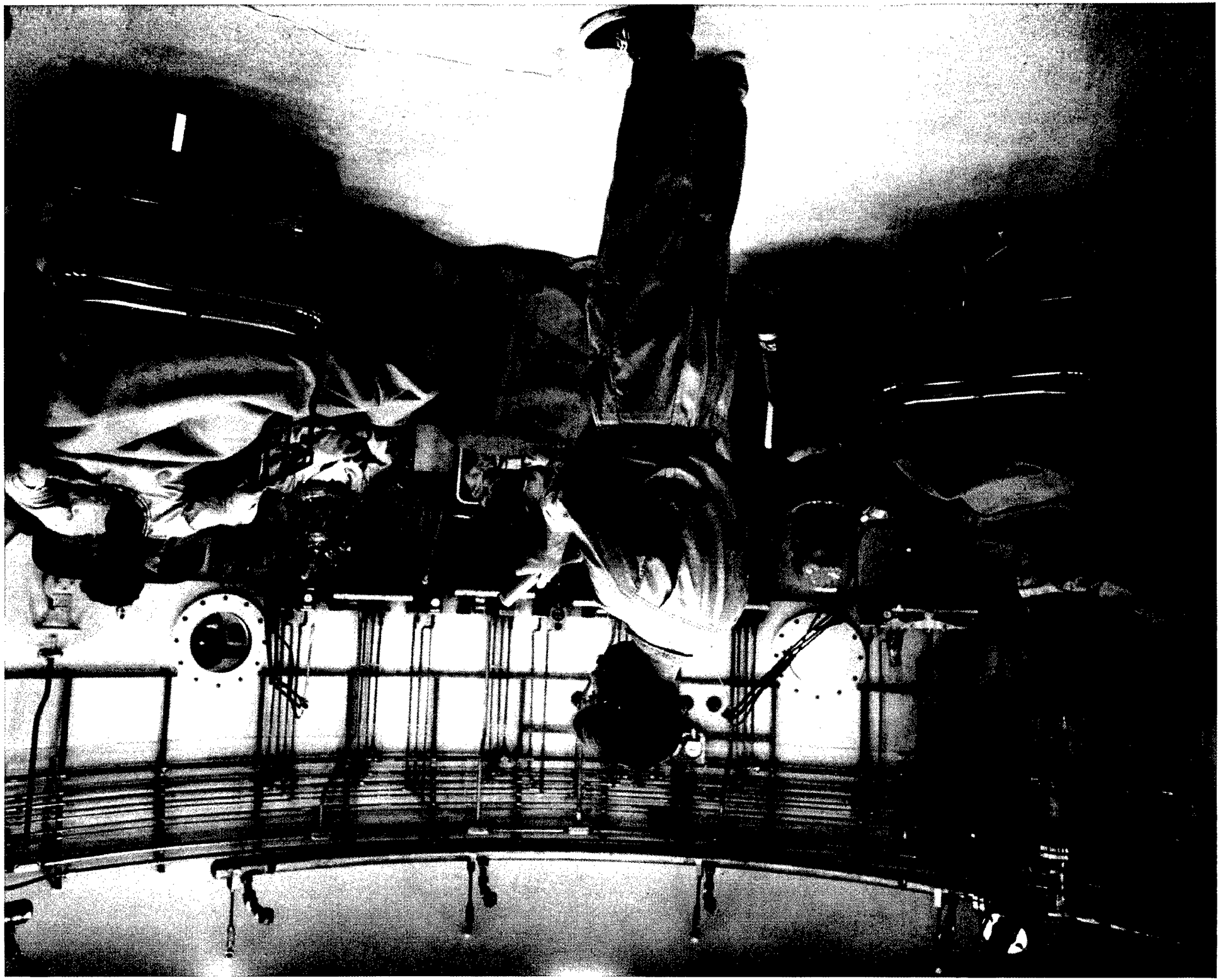
A plastic optical device that transmits light waves as efficiently as glass waveguides and fibers will aid in the development of ultra-high speed optical computers for Air Force and commercial applications. Designed for transmission of light waves with less than a 0.04 decibel per centimeter loss, the revolutionary polymer integrated optic waveguide achieves this light value through refinements in the production process that nearly eliminates light wave scattering. The lightweight plastic waveguide, shown above magnified 1200 times, is smaller in cross section than a human hair, and is designed to fit on a computer chip.

Accomplishment

Under a program sponsored by the Materials Directorate, Laser-Matter Laboratories of Albuquerque NM, developed a plastic optical device that transmits light waves as efficiently as glass waveguides and fibers, yet weighs 60 percent less than glass. This polymer integrated optic waveguide, smaller in cross-section than a human hair, can fit on a computer chip to save weight and space while transmitting light waves in photonic systems such as optical computers and other ultra-high speed solid-state devices.

Background

Regardless of the size of an electronic system or how rapidly it operates, there is always some element of time lost while switching between the on and off state and today's electronic systems are approaching their speed limit. To overcome this critical limitation, optic systems based on photonics are under development using light waves which can change from an on to off state at a rate of 20 gigahertz, or faster, for the case of electro-optical switching. All-optical switching has the potential of reaching the 10 terahertz regime. In photonic systems, transparent ducts called waveguides are used to transmit light waves in much the same way as metal strips carry current in electronic systems. Silicon dioxide glass fibers offering low light loss rates have been used for years in telecommunications, but are difficult to work with on the small scale required for optical processing. Polymers are easier to process than glass, offering lower costs for both materials and processing. The major problem with polymer waveguides has been relatively high scattering and weakening of light waves. Laser-Matter Laboratories' goal was to develop a polymer integrated optic waveguide offering minimal light wave loss by reducing surface scattering, side scattering and bulk scattering. The result was a waveguide capable of transmitting light waves with 94 percent less scattering than waveguides made of other plastics.



New Material Process Control System Benefits Medical Community

Payoff

The Infoscribe™ system will improve treatment effectiveness for patients requiring hyperbaric oxygen therapy by providing millisecond data resolution during treatment. By gathering data on skin, breath parameters and chamber conditions in real time for in-depth analysis, the Infoscribe™ system can maximize treatment effectiveness and insure patient safety.

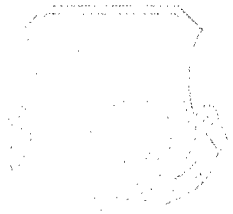
Accomplishment

A process information system, developed jointly by the Materials Directorate and InfoScribe™ Technologies, Dayton OH to improve the precision and reliability of advanced materials processing systems, is being used by the USAF Medical Center at Wright-Patterson Air Force Base to improve medical treatment for patients with complicated body tissue wounds. By supporting real time data collection and tracking for several critical parameters in hyperbaric oxygen therapy, their InfoScribe™ system helps to promote prompt healing. The system also helps to anticipate and prevent problems during treatment.

Background

Damaged body tissue that is deficient in blood and oxygen cannot heal. Hyperbaric oxygen therapy, a method of delivering high doses of oxygen to body tissues, often provides a therapeutic effect to damaged tissues. The USAF Medical Center at Wright-Patterson has a three-chamber hyperbaric therapy facility, where patients are treated inside a pressurized air chamber while breathing 100 percent oxygen through an oxygen hood. The oxygen delivered to a patient's injured tissues to promote prompt healing is increased by as much as 15 times. For maximum effectiveness and safety during treatment, a number of skin and breath parameters and chamber conditions must be simultaneously monitored and controlled for each patient. Data was previously recorded in this facility either manually or on a strip chart, procedures which made process control and analysis difficult. The InfoScribe™ system is used to collect data from oxygen, carbon dioxide and temperature monitors on the skin. This modular system permits real time recording of all data for rapid access and analysis, so that patient progress can be tracked and adjusted while treatment is proceeding. Its millisecond data resolution provides accurate measurement of cause and effect factors. The system includes a datalogger, the centralized data source for all InfoScribe™ modules and archived data files. Independant modules can be added or exchanged depending on the particular application, with no effect on the datalogger or other system modules. No modifications are necessary in the primary datalogger code when changes are made in the system setup. InfoScribe™ modules encompass data acquisition, process control, post-process data analysis and conversion of data to multiple external analysis formats. InfoScribe™ system modules interact through a common Macintosh-based language called Inter-application Communication.

BT/Control MCM



Built-in Test/Fault Isolation Test (BIT/FIT) Circuitry is Applied to F-22 Radar Support Electronics

Payoff

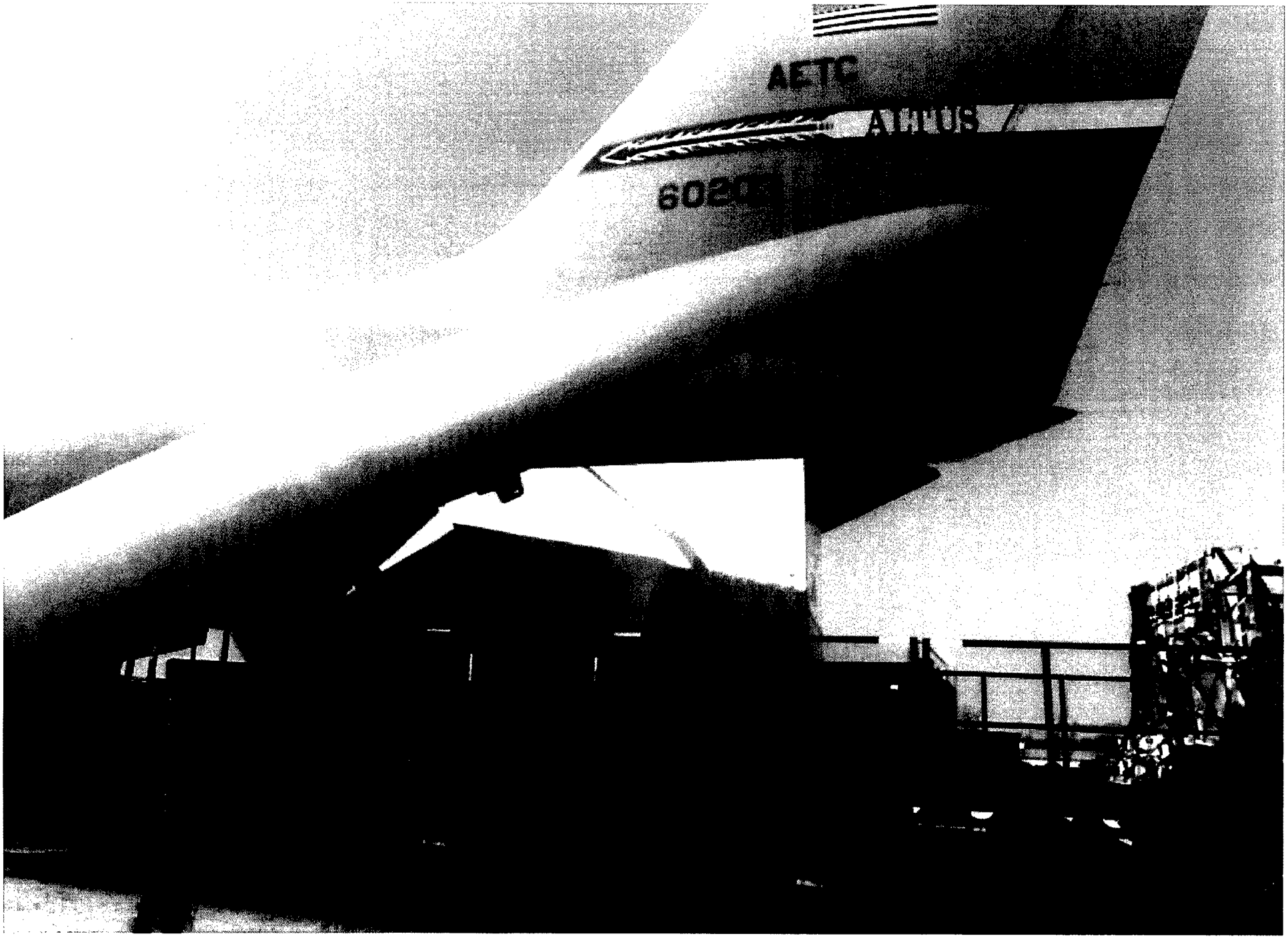
The incorporation of BIT/FIT circuitry in radio frequency (RF) modules improves troubleshooting/diagnostics and reduces system/module repair and maintenance time. It also reduces the number of spares and enables an effective implementation of two-level maintenance for RF modules. As much as 60 percent of the traditional depot level testing will be avoided. The inclusion of this nonobtrusive technology in the F-22 radar support electronics lays the foundation for significant life-cycle cost savings.

Accomplishment

Under a program sponsored by the Avionics Directorate's Systems Avionics Division, the feasibility of implementing advanced BIT/FIT circuitry in RF Standard Electronic Modules (SEM), was demonstrated. The BIT/FIT feature provides an increased level of real-time/in-flight feedback of operational environment and fault logging capability commensurate with modern avionics systems. This new compact BIT/FIT circuitry is non-obtrusive to the performance of sensitive RF circuitry.

Background

Traditional RF electronics in conventional avionics SEM architecture do not provide for sufficient BIT/FIT capabilities due to space constraints. This has led to high maintenance costs and, as a result, low RF avionics availability. To address the need for improving RF avionics availability, the Avionics Directorate initiated the Advanced Aircraft Avionics Packaging Technology (AAAPT) Program in 1989. Prior to this program, maintenance costs using BIT/FIT techniques were primarily addressed for digital electronics and did not include SEM. The AAAPT program included the design, fabrication, test and manufacturability of the BIT/FIT circuits/packaging using a low temperature co-fired ceramic (LTCC) material system technology to improve RF electronics performance awareness monitoring in real-time. The benefits of this technology were demonstrated when it was employed to redesign the functions of the existing Intermediate Frequency Receiver of the F-16 APG 68 C/D radar.


AETC
ATHLOS

Mobile Composite Patch Facility Reduces Aircraft Maintenance Turn-Around Time

Payoff

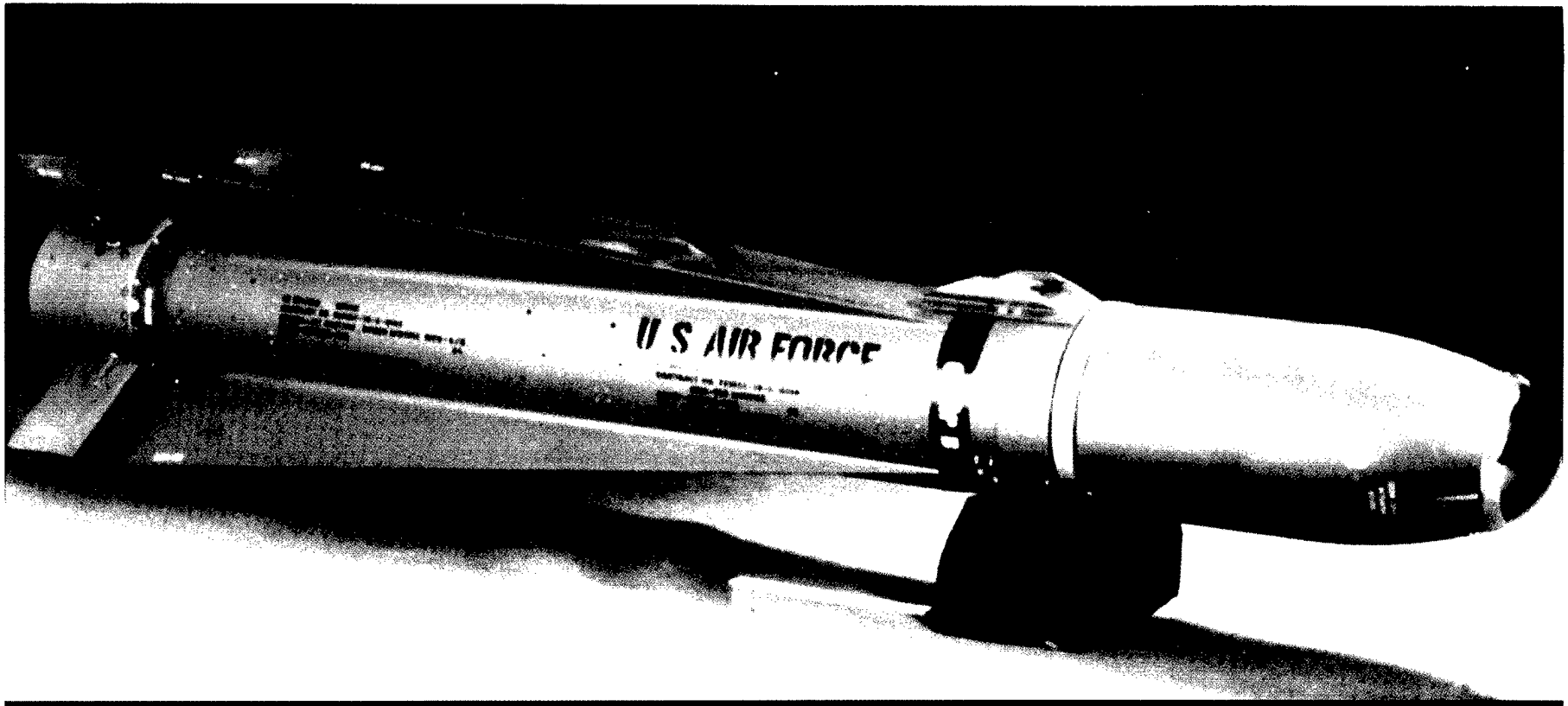
The self-contained mobile repair facility offers quick turn-around time for Air Force aircraft that need depot-level composite patch repairs. By achieving on-site repairs to damaged or broken aircraft, time spent out of action can be reduced by as much as 90 percent by eliminating the logistics of getting into and out of the depot.

Accomplishment

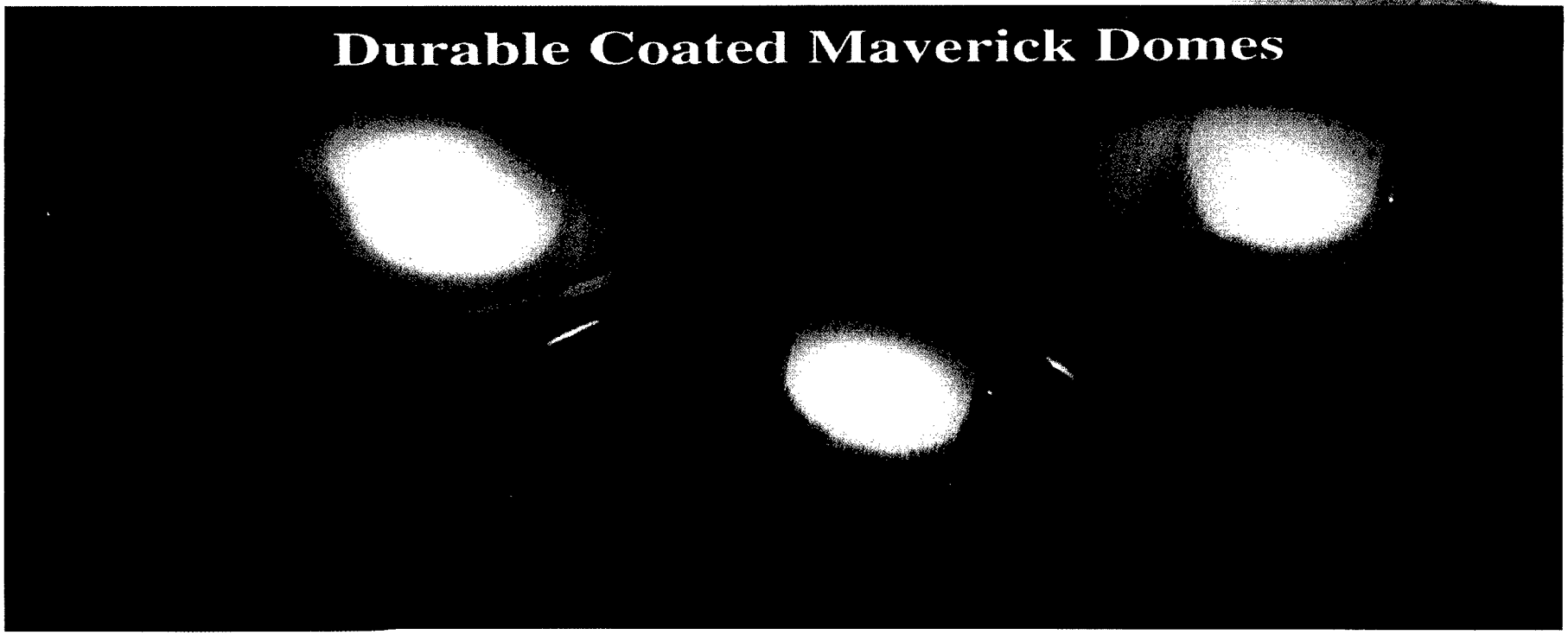
Wright Laboratory's Materials Directorate teamed with the Technology and Industrial Support Directorate of Warner Robins Air Logistics Center (WR-ALC) to help develop a capability to deploy depot-level composite patch repair technology anywhere in the world. The self-contained mobile composite patch facility concept, devised by WR-ALC, can reduce the time an aircraft that is damaged through wear and fatigue is out of service from several weeks to a matter of days.

Background

Finding ways to keep the Air Force's aging aircraft fleet in flying condition and in a state of readiness is becoming more important as U.S. military forces draw down in size and budgets become leaner. Engineers from the Materials Directorate developed a composite patch repair installation process that enables immediate in-the-field repair of metal aircraft structures that are damaged through wear and fatigue. In 1994, when more than 120 C-141 Starlifter transports were grounded due to fatigue cracks around wing weep holes, WR-ALC asked the Directorate to help manage a project to adapt their repair process to repair the cracks. Since repairs like these typically have to be worked around scheduled maintenance projects, this situation had overloaded the ALC's repair capability, resulting in the aircraft being out of service for months. The mobile composite patching facility, constructed jointly by the Materials Directorate and the University of Dayton Research Institute, helped speed the return of the damaged C-141 aircraft to operational status. This totally self-contained mobile unit comes equipped with its own generator, air compressor, freezer, surface prep equipment, autoclaves, infrared heaters and computer-controlled hot bonders. Field-level repairs are made using a variety of patch material, including boron and graphite. The facility is set up in a trailer that can be transported on C-130, C-141, C-5 or C-17 aircraft. The mobile composite patch facility has been used successfully at several Air Force bases to repair fatigue cracks on C-141 aircraft. Because the logistics of getting into and out of the depot are eliminated, the aircraft can be returned to service very quickly.



Durable Coated Maverick Domes



New Protective Coating Doubles the Service Life of Missile Infrared Sensor Domes

Payoff

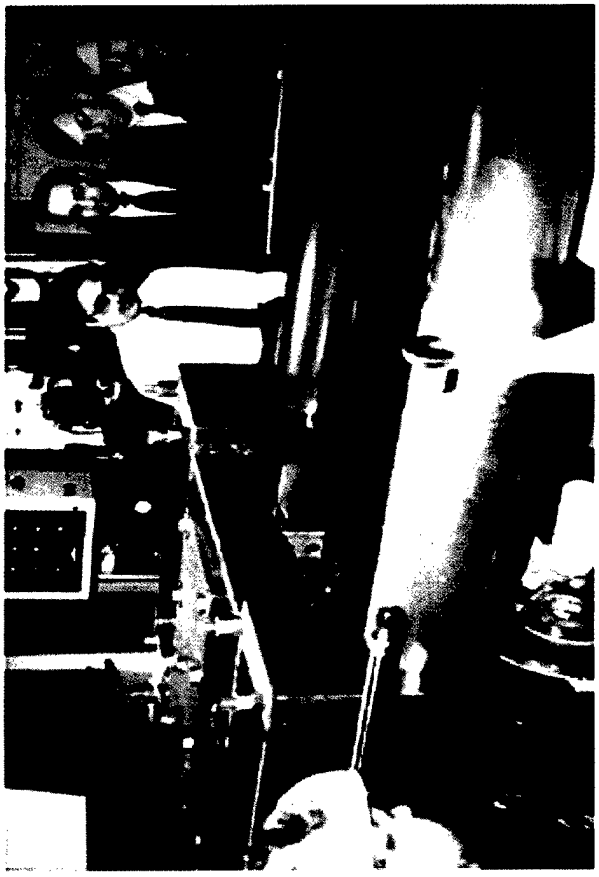
Application of new coating technology to infrared sensor domes for Maverick missiles is projected to double the life expectancy of these domes and save the Air Force $4 million in replacement and maintenance costs. The new improved dome, which has been selected as the preferred spare for the Maverick, can be used to accommodate infrared sensor protection requirements Air Force wide.

Accomplishment

The Materials Directorate and Raytheon Company of Lexington MA developed a new multiple-layer coating that improves the protective capability of domes used to protect infrared sensors on Maverick AGM-65 air-to-surface missiles. This zinc sulfide/ yttrium oxide coating maintains the required transparency for the sensor, while improving the dome's protective capability against airborne debris by a factor of 2 to 5 times the durability of the conventional dome.

Background

Infrared sensors are used on many Air Force airborne systems for navigation, threat detection and precision targeting. These sensors perform their functions through domes that protect them from direct exposure to harsh flight environments and are transparent to infrared radiation. The domes, which are damaged from exposure to air flow, dust, rain and other airborne debris during flight, must be periodically replaced to maintain system performance. The Maverick AGM-65 air-to-surface missile's nose-mounted infrared sensor is protected from damage by a zinc sulfide dome. The multiple-layer coating, developed by the Materials Directorate and Raytheon Company to increase the dome's service life, is made up of thin layers of zinc sulfide for rain erosion protection and yttrium oxide for sand and dust protection which is deposited directly onto the zinc sulfide dome surface. This coating maintains the required transparency for the missile's infrared sensor, while improving the dome's protective capability. Following development of the coatings, domes with the new coating were scaled to the correct size and configuration for Maverick missiles by the Materials Directorate, the Reliability and Maintainability Technology Insertion Program Office, the Advanced Infrared Search and Track Program Office and the Ogden Air Logistics Center, Hill AFB. The improved dome will be initially used as a training dome on the Maverick AGM-65 missile. The current training domes are subject to severe wear due to extensive captive-carry flights. The new protective coating is also being considered for use with Low Altitude Night Targeting Infrared Navigation and Targeting Systems, the F-22 advanced tactical fighter and the Navy's F-18 Hornet.



Air Force Office of Scientific Research (AFOSR) Star Team Awards

Payoff

The accomplishments of the 1995 Wright Laboratory Star Team leaders and team members strengthen the critical role of basic research within the Air Force Science and Technology Program. Each team has demonstrated, through their scientific and engineering excellence, world class status in their respective areas of research. They serve as role models in showcasing Wright Laboratory's research achievements.

Accomplishment

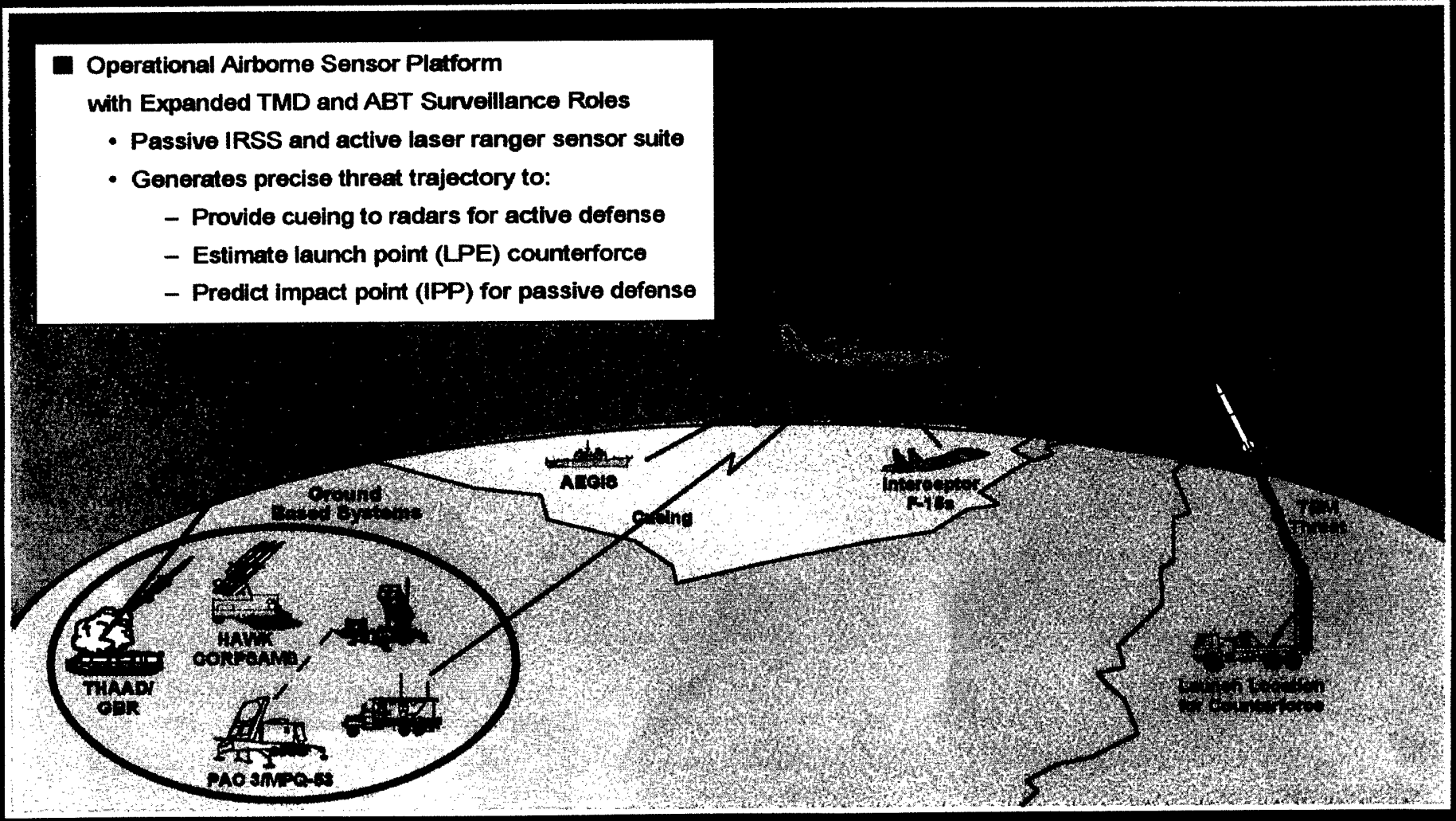
Three Wright Laboratory teams of scientists and engineers received the 1995 Air Force Office of Scientific Research (AFOSR) Star Team Award for excellence in basic research. The award rewards team achievements, fosters excellence within the research community and highlights the critical role of basic research within the Air Force's broad technology spectrum.

Background

As part of the annual review of basic research tasks in the laboratories, AFOSR selects teams of researchers that have proven, through their track record, world class status in their chosen areas of research. The work performed by the High Temperature Composites research team is led by Dr. Ronald J. Kerans of the Materials Directorate. They have pioneered research in the development of fiber-reinforced, ceramic matrix composite materials that combine high temperature capability, light weight, high damage tolerance and low observable characteristics. Members of the Processing Fundamentals of Metallic Structural Materials Team, led by Dr. Lee Semiatin of the Materials Directorate, are recognized leaders in establishing methods to design and control fabrication processes used to produce high integrity, complex shape components for advanced airframe and propulsion systems. Understanding fundamental combustion processes important to gas turbine combustors has enabled the Aero Propulsion and Power Directorate's Dr. W. Melvyn Roquemore and his Combustion Research Team to develop a novel trapped vortex combustor design that produced superior flame stabilization and low exhaust emissions.

Airborne Surveillance for Theater Missile Defense Mission

- Operational Airborne Sensor Platform
  with Expanded TMD and ABT Surveillance Roles
  - Passive IRSS and active laser ranger sensor suite
  - Generates precise threat trajectory to:
    - Provide cueing to radars for active defense
    - Estimate launch point (LPE) counterforce
    - Predict impact point (IPP) for passive defense



Silent Attack Warning System (SAWS) Transitioned to Ballistic Missile Defense Organization

Payoff

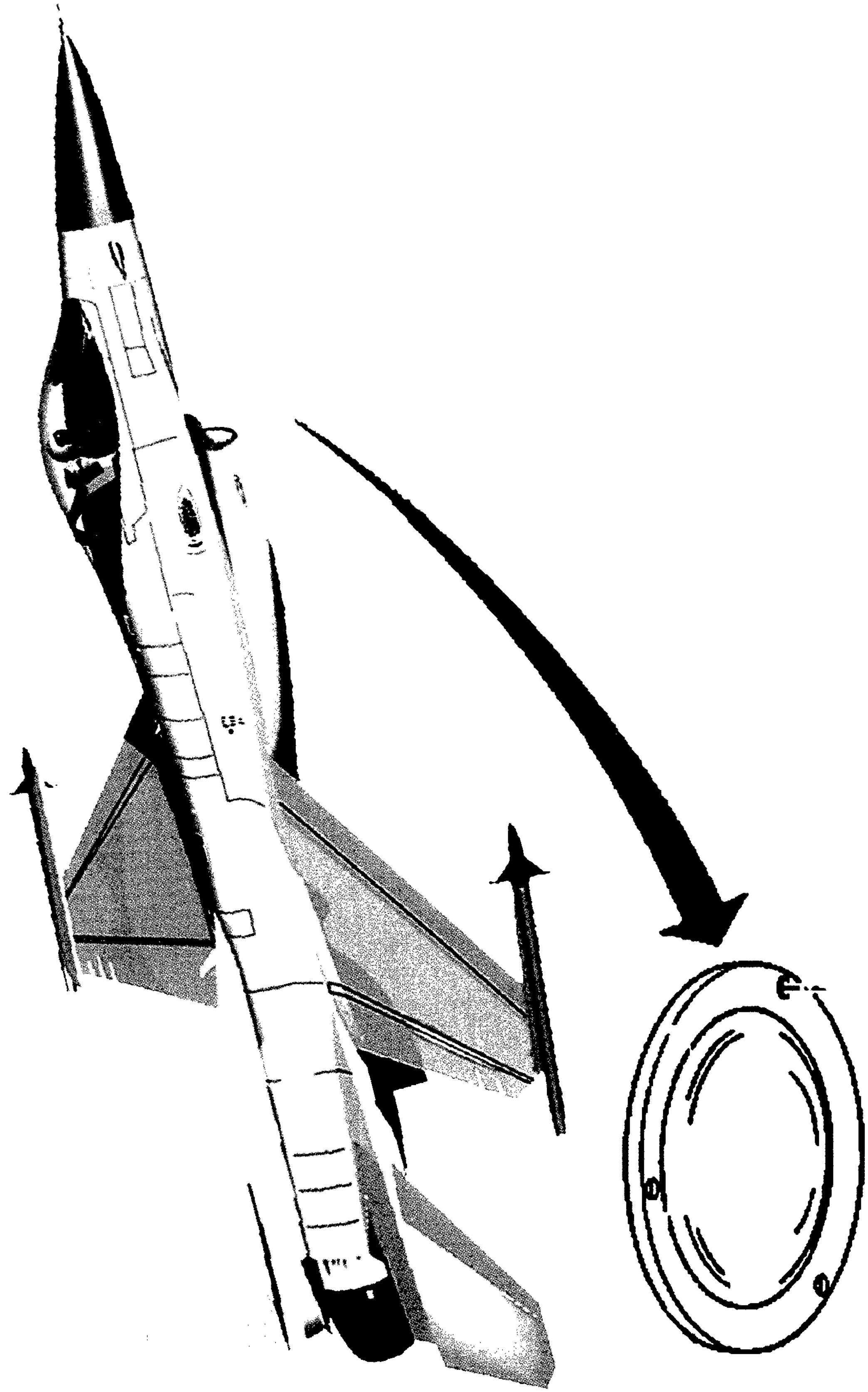
The transition of SAWS equipment and software enabled the Ballistic Missile Defense Organization to accelerate their demonstration/validation program for upgrading Airborne Warning and Control System aircraft for theater ballistic missile defense. Reuse of the SAWS by the EAGLE program reduced program risk and avoided significant cost and schedule impacts associated with development of EAGLE's wide area surveillance system.

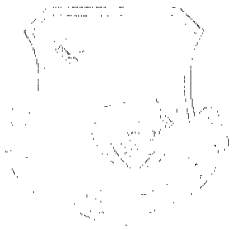
Accomplishment

Engineers from the Avionics Directorate's Electronic Warfare Division developed and demonstrated an effective infrared threat warning system to protect aircraft from missile and aircraft attack. The SAWS uses a linear infrared detector array and sophisticated algorithms to detect and declare over a large area while rejecting infrared clutter and maintaining very low false rates.

Background

The detection and declaration of missile and aircraft threats are important to the survivability of Air Force platforms in a hostile environment. Although conventional infrared threat warning systems have demonstrated an excellent capability for threat detection at long ranges, in the past they have had difficulty in declaring hostile threats due to an inability to reject infrared clutter. As a result, data cannot be processed in time to initiate a defensive response, resulting in high false alarm rates or unacceptably long declaration times. The SAWS hardware uses a linear infrared detector array and sophisticated algorithms to detect and declare hostile aircraft and missiles. The approach includes use of spatial filtering, multi-color discrimination and temporal processing to provide the declaration ranges necessary to initiate defensive responses. SAWS demonstrated aircraft and missile declaration at long ranges, with low false alarm rates, during extensive flight tests in 1990-91. The SAWS hardware and algorithms have been transitioned to the Ballistic Missile Defense Organization for use in the EAGLE Demonstration/ Validation Program. This program is upgrading Airborne Warning and Control System aircraft for theater ballistic missile defense.





Injection Molding Technology Meets Current and Future Aircraft Transparency Requirements

Payoff

Production injection molding of F-16 navigation lenses provide diffuse-colored lighting critical to formation flying. The maturation of injection molding technology under the Next Generation Transparency program will include an order of magnitude reduction in transparency manufacturing costs and improved supportability through reduced spare parts.

Accomplishment

A new process for molding frameless aircraft transparency systems, developed under a program sponsored by Wright Laboratory's Flight Dynamics Directorate, has led to production molding of F-16 navigation lenses and industry inclusion of injection-molded transparencies in their baselines for Joint Advanced Strike Technology (JAST) production. The F-16 system becomes the first Department of Defense aircraft to benefit from successful transition of the technology. The technology transfer reflects industry's acceptance of the potential for the new fabrication process to balance performance and affordability.

Background

The new technique makes frameless transparencies, such as lenses and canopies, by injecting molten plastic resin into a mold, bypassing the time-consuming and expensive steps necessary in the current method. Wright Laboratory, Warner-Robins Air Logistics Center, Aeronautical Systems Center and the JAST Program Office are teaming to jointly mature this technology under the Next Generation Transparency (NGT) program. The objective of NGT is to demonstrate and validate the ability of injection-molded frameless transparency technology to be incorporated into an integrated design that meets future aircraft mission requirements. Operational deficiencies, which will be addressed, include: cost of transparency production and spares driven by high unit cost and high spares requirements resulting from subsystem unreliability; range penalties driven by excess weight resulting from current manufacturing methods; signature/observability and helmet mounted display vision penalties driven by the inability to precisely and repeatably control moldline geometry; reduced sortie generation rate due to excessive time for change-out; and supportability/logistics burdens, such as excessive airlift support and manpower to sustain operations driven by high parts count. Technologies to be integrated into the low cost frameless transparency concept under NGT include: advanced abrasion-resistant coatings, mission compatible optics, 500 knot bird impact protection, rapid transparency change-out during combat turns and combat hazard protection.

Materials Directorate Personnel Receive Recognition

Payoff

The Engineering and Science Awards, presented by the Engineering and Science Foundation/Affiliate Societies Council of Dayton, acknowledged the role of research and development within the Air Force's broad technology spectrum. The 1996 awards recognized the technical leadership and research in materials and processes performed by Dr. Vincent J. Russo, Dr. Gail J. Brown and Dr. Ruth Pachter that will contribute to the technical superiority of tomorrow's Air Force.

Accomplishment

The Engineering and Science Awards, presented annually by the Engineering and Science Foundation/Affiliate Societies Council of Dayton, honor outstanding Dayton area engineers and scientists for significant achievements in their professions and community. Dr. Vincent J. Russo, Dr. Gail J. Brown and Dr. Ruth Pachter of the Materials Directorate were among the 1996 winners recognized for technical leadership and scientific achievements.

Background

As director of the organization that provides the entire range of materials and processes research for the Air Force, Dr. Russo's award was in the category of Technical Leadership. He spearheaded several initiatives to integrate materials and process technologies with major Air Force, Department of Defense and national and local programs. Dr. Russo also championed programs with local school systems that included assisting high school math and science teachers in gaining laboratory research experience. Dr. Brown was recognized for research in the development of materials to improve the performance of infrared sensors used on advanced Air Force imaging systems. She has conducted pioneering work that has advanced the fundamental understanding, design, development, assessment and performance of novel semiconductor materials. Her research leadership will enable the Air Force to maintain its technological advantage in electronic and optical systems. Dr. Pachter, a co-located National Institute of Standards and Technology scientist, provided contributions to the development of advanced nonlinear optical materials for laser hardening applications. Using extensively parallel computing capabilities, Dr. Pachter's work has led to the design of novel multi-functional materials and provided a fundamental understanding of the underlying principles that govern the properties of such materials.


U.S. AIR FORCE

Failure Analysis Team Receives Armstrong Laboratory Support Award

Payoff

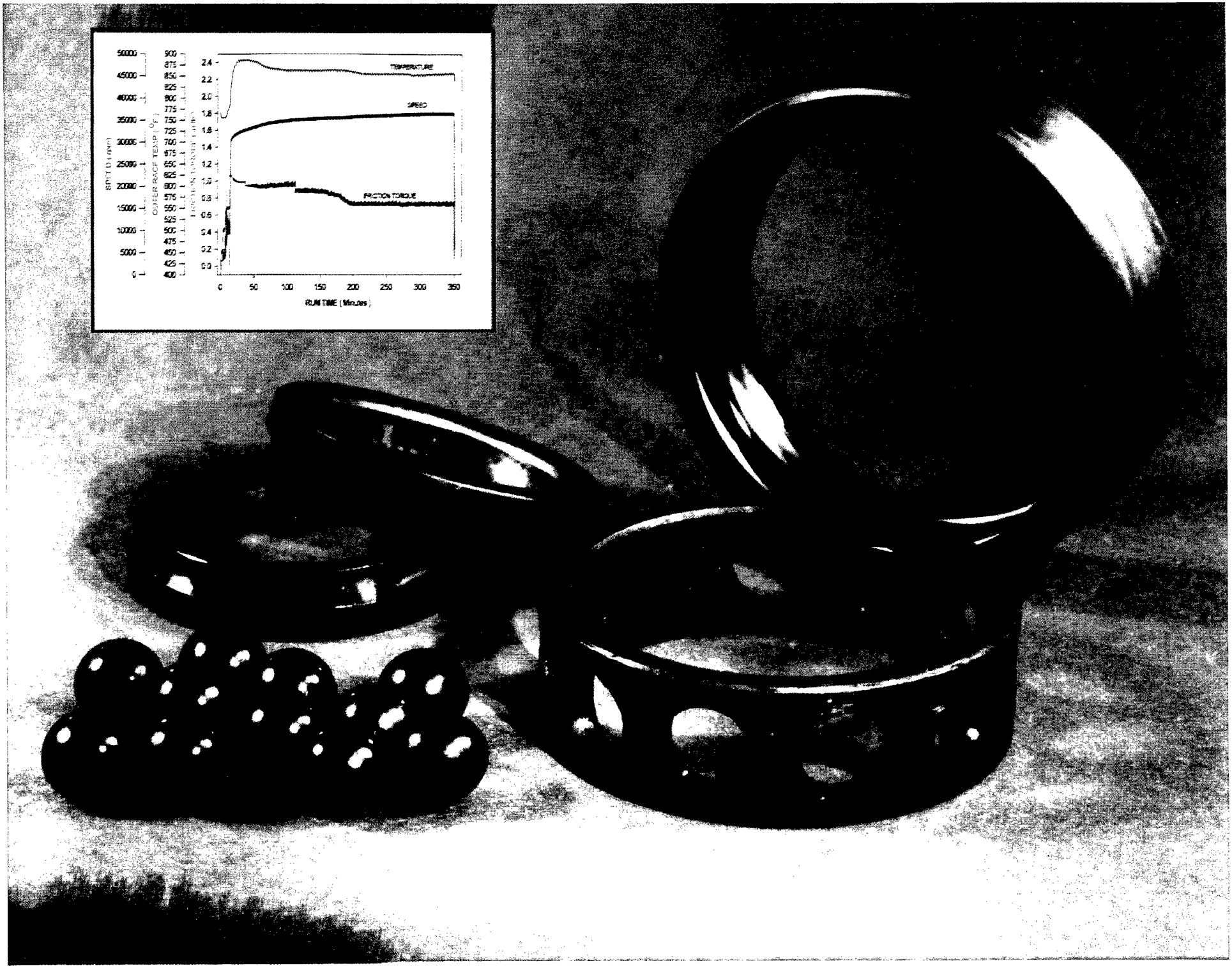
Support provided by a team of engineers from the Materials Directorate was instrumental in returning Armstrong Laboratory's Dynamic Environment Simulator (DES) Centrifuge back to full operation. This effort showcases the strong interface between the Laboratories within the Air Force Science and Technology Program that is critical to the foundation for the technical superiority of tomorrows Air Force.

Accomplishment

A team of engineers from the Materials Directorate performed an in-depth failure analysis that determined the extent of damage to the upper bearing system of Armstrong Laboratory's DES Centrifuge. Recommendations for repair to the system's hydrostatic bearing pads and trunnion surface were instrumental in returning the centrifuge research facility back to full operation. Larry Perkins, John Brausch and Captain Robert Ware of the Directorate's System Support Division were recognized for this accomplishment when they received the 1995 Armstrong Laboratory Support Award.

Background

In order to investigate the effects of sustained G forces on pilot performance, define physiologic changes, develop more effective anti-G equipment and tactics and provide specialized training, Armstrong Laboratory maintains a one-of-a-kind DES at Wright Patterson AFB. This three-axis centrifuge has been used since 1969 to simulate acceleration stresses encountered by pilots and astronauts. The DES system has a spherical cab capable of simulating all inertial G forces for test subjects, a 19-foot radius to the center of the cab, a capability of generating 20 Gs at 56 revolutions per minute and a weight of 186 tons. It is supported by a hydrostatic bearing system consisting of six radial pads arranged around the top and bottom of the trunnion. During an extensive test series in May 1994, the upper bearing system seized up and failed, bringing the operation of the DES to a grinding halt. To avoid a delay in facility operation, Armstrong Laboratory's Crew Systems Directorate requested Materials Directorate's assistance. Initial nondestructive testing of the damaged trunnion and bearing pad surfaces revealed extensive scratching and cracking. Some cracking in the six bearing pads exceeded a depth of one-fourth inch. The Materials Directorate engineers recommended that the bearings be replaced, and that all cracked and heat-affected materials on the trunnion surface be removed and replaced by welding and machined to tolerance. Nondestructive testing performed after the task was completed revealed no cracks.


TEMPERATURE
SPEED
FRICTION TORQUE
RUN TIME (Minutes)
0
50
100
150
200
250
300
350

Light Weight Lubrication System Reduces Expendable Engine Weight

Payoff

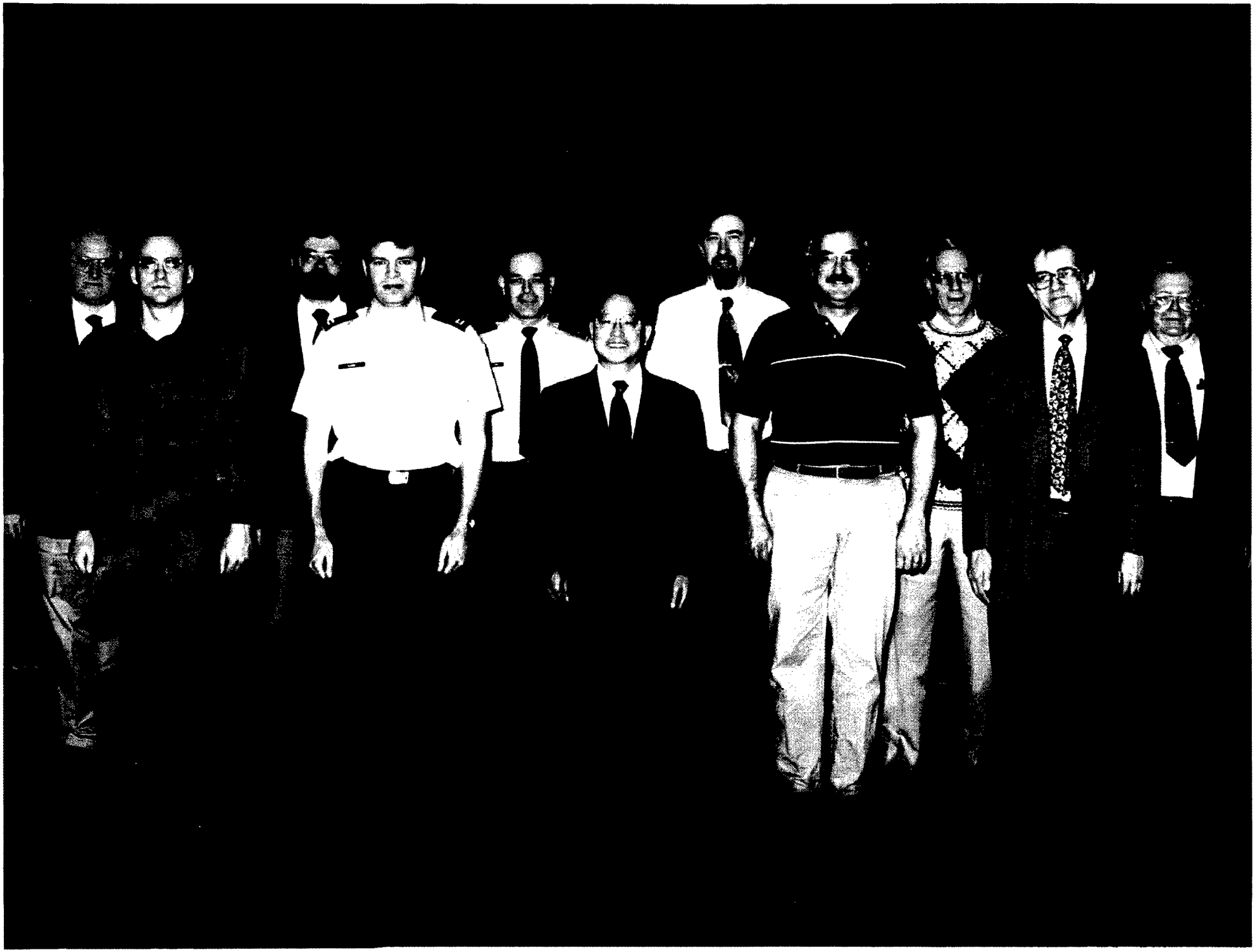
Utilization of a light weight lubrication system (less than 5 pounds) in an expendable engine for unmanned air vehicles and cruise missiles will eliminate 25 pounds of engine hardware. This system, using rolling element bearings, carbon-carbon (C-C) cages and vapor phase lubrication, will result in improved engine performance (through reduced cooling requirements) and reduced engine cost (through lower parts count).

Accomplishment

A C-C composite bearing cage was tested by the Aero Propulsion and Power Directorate for thirty-two hours in 30 millimeter bore ball bearings at speeds of 35,000 revolutions per minute, temperatures of 750°F to 950°F, and thrust loads of 100 to 400 lbs. This is the first time that rolling element bearings have achieved stable operation at these extreme conditions.

Background

The development of high speed bearings that operate beyond the temperature limits of conventional synthetic liquid lubricants has been a research objective for more than forty years. In the early 1990's, in-house research performed in the Aero Propulsion and Power Directorate edged closer to this objective by applying organic phosphate vapors to high temperature bearing surfaces. This method proved successful for high speed bearings; however, lubrication of the steel bearing cage still posed a problem. Based on their previous success with phenolic (thermosetting plastic) bearing cages at low temperatures, and knowledge of the high temperature properties of C-C composites, Directorate in-house researchers postulated that C-C composites would be an ideal temperature bearing cage material. This material's properties include a low coefficient of friction, extremely low wear rates, high thermal conductivity, high temperature strength, low density, and good damping characteristics. Collaboration with the Materials Directorate identified B.F. Goodrich Aerospace of Santa Fe Springs CA as the most promising source for C-C bearing cage material. During the period of June 1995 to February 1996, a single C-C bearing cage accumulated over thirty-two hours of testing. This technology has dual use potential where high speed, high temperature bearings are required.



Materials Research Team Receives Lab Consortium Award for Technology Transfer

Payoff

In recognition of innovative technology transfer, that led to the commercial availability of advanced nonlinear optical crystals for high performance laser systems, an Air Force materials research team was presented a 1996 Federal Laboratory Consortium Award for Excellence in technology transfer.

Applications enabled by the availability of these crystals, such as increased aircraft protection from heat-seeking missiles and remote sensing of chemical and biological agents, enhances the Air Force's reputation in material science and engineering.

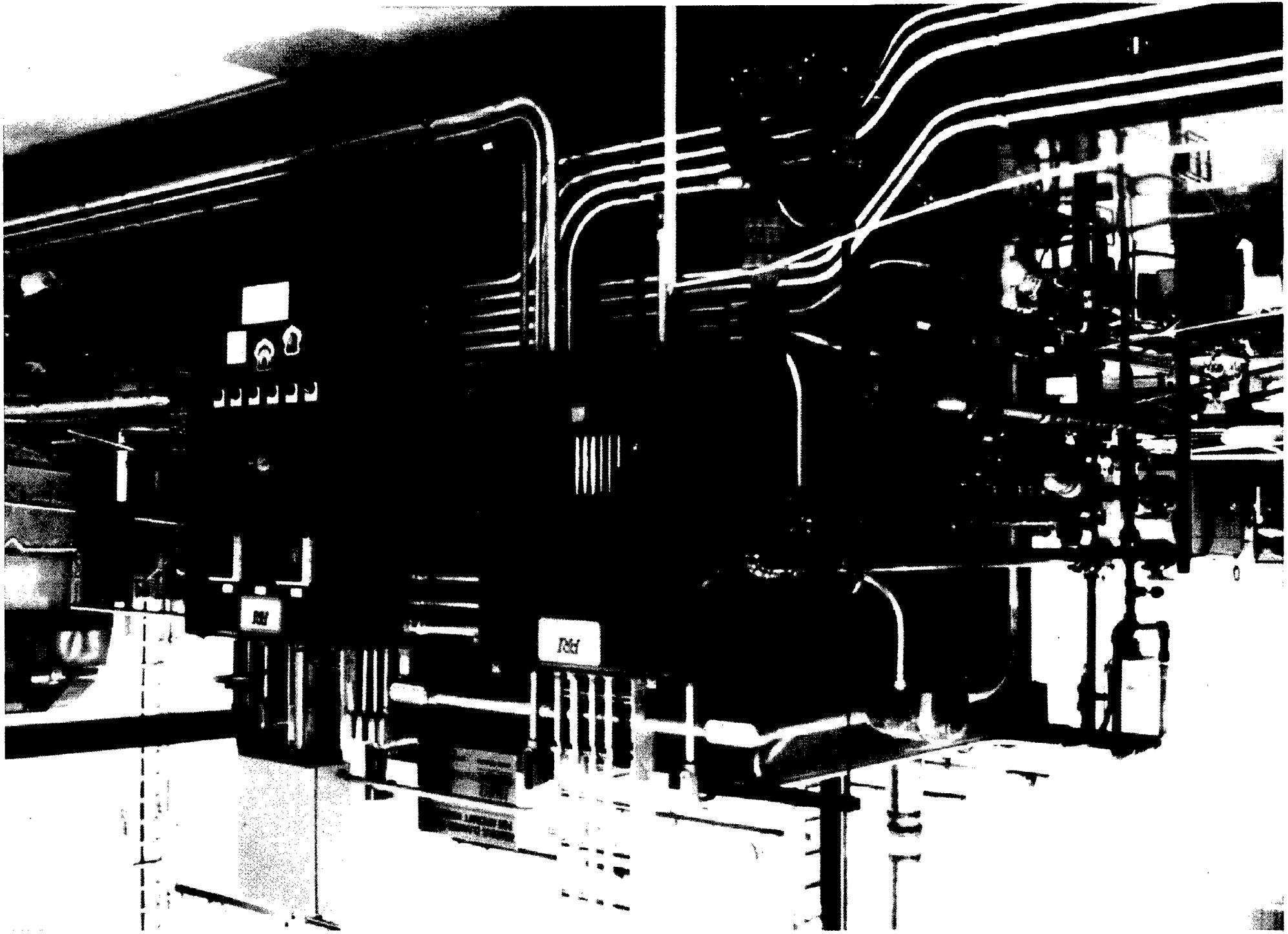
Accomplishment

An Air Force materials research team, led by scientists from Wright Laboratory's Materials Directorate, received a 1996 Federal Laboratory Consortium Award for Excellence in technology transfer. It was recognized for transferring the technology for production of advanced optical quality nonlinear optical (NLO) crystals in real-time to U.S. crystal manufacturers by integrating technology transfer directly into the research and development process. The team included scientists from Wright Laboratory's Materials and Avionics Directorates, Rome Laboratory, Phillips Laboratory, Seiler Laboratory and the Air Force Institute of Technology.

Background

Annually, the Federal Laboratory Consortium, a network of over 500 federal government research and development organizations, presents awards for excellence in technology transfer efforts to a select number of individuals or groups who demonstrate their commitment by actively working to transfer a technology or process to the public or private sector. The Air Force research team of scientists, led by Dr. F. Kenneth Hopkins of the Materials Directorate, identified six new optical quality NLO crystals that provide new, discrete wavelengths that previously were not available, as well as, new wavelength tunability with high-power. These crystals include zinc germanium phosphide, rubidium titanate arsenate, potassium titanate arsenate, gray-track resistant potassium titanate phosphate, gallium selenide and cadmium germanium arsenide.

After identifying these promising new crystals, the team sponsored development programs with Sanders of Nashua NH, Crystal Associates Inc. of Waldwick NJ and Northrop-Grumman of Pittsburgh PA. To expedite the characterization and in-depth physical understanding of these crystals and to speed up development of material processing techniques, the Air Force research team established a two-way information flow. Several critical processing techniques developed solely by the Air Force were transferred to the companies while other processing methods were developed in collaboration. Such cooperation moved the technology directly into the national technology base and led to the swift development and commercial availability of new NLO materials.



New System for Cleaning Honeycomb Material is Environmentally Safe

Payoff

The new aqueous spray system for cleaning aluminum components can effectively and economically clean and dry both single-stage and multi-stage bonded honeycomb parts at production rates. This system, which allows use of the cleaning agents for a period of up to a year, is in full compliance with all Environmental Protection Agency regulations governing ozone depleting chemicals.

Accomplishment

Under a program sponsored by the Manufacturing Technology Directorate, BDM International Inc. of Albuquerque NM developed a new environmentally safe aqueous cleaning system for honeycomb materials used in bonding structural components. A prototype system was used to clean and dry honeycomb parts up to 6 feet by 4 feet by 2.5 inches thick in less than one hour.

Background

One of the critical operations of aircraft maintenance is cleaning structural honeycomb material. This cleaning process is essential because the honeycomb core material must be completely free of any contaminant or moisture before being bonded to skin panels. Previous degreasing operations used Trichlorethane (TCA) as the cleaning solvent. TCA is an ozone depleting chemical that was banned by Environmental Protection Agency regulations in December 1995. The BDM developed prototype cleaning system uses an aqueous cleaning technology that results in a fully environmentally compliant cleaning system. BDM concluded, after examining data on alternative cleaning processes, that an aqueous process had the highest potential for providing an environmentally acceptable, economical and effective alternative cleaning process in the near term. During the testing and analysis phase of the program, the cleaning effectiveness of aqueous systems proved to be equal to, or better than, the TCA vapor degreasing process. Detailed equipment specifications were developed for the prototype with the objective of accommodating different honeycomb part sizes. A wash chamber provides an extensive spray of cleaning solution and rinse into each honeycomb core cell. The cleaning process involves a hot wash cycle, two rinse cycles and an air blowoff cycle to remove water from each of the cells. The drying chamber, a convection oven for throughly drying the honeycomb, is the second critical element of the system. This system, has been installed at the National Defense Center of Environmental Excellence (NDCEE) in Johnstown PA where limited engineering support from the NDCEE staff, is available for demonstration and evaluation of specific cleaning requirements.


HTS SWITCHED
FILTER BANK
RF INPUT
J1
J2
RF OUTPUT
REJECT CHANNELS
TEMPERATURE
CONTROL INTERFACE
TTL
J8
SUPERCONDUCTOR
TECHNOLOGIES
J3
ON
AC INPUT
OFF

New Filter Improves Battlefield Awareness and Enhances Survivability

Payoff

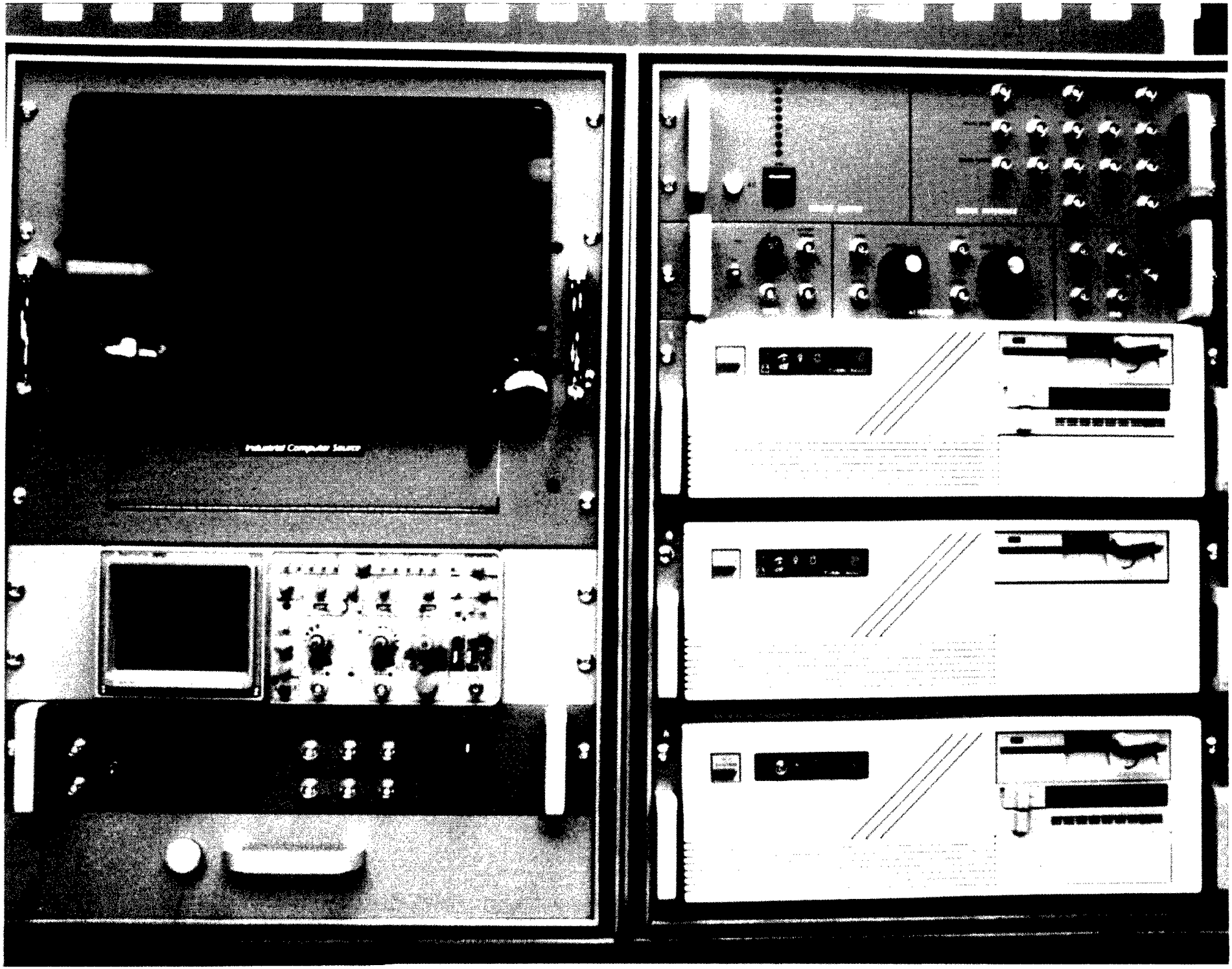
The new switchable electronic filter, shown above, will improve a pilot's combat situational awareness by reducing confusion between enemy threat signals and friendly transmissions. This 24-filter filterbank is 1,000 times faster at reducing interference and less temperature sensitive than current microwave filter technology. It will improve an aircraft's survivability in a combat environment by as much as 55 percent.

Accomplishment

Under a program sponsored by the Avionics Directorate, Superconductor Technology Inc. of Santa Barbara CA, developed a high-temperature superconducting (HTS), switchable band reject filterbank that removes friendly and hostile interference signals in an aircraft's defensive system. By filtering unwanted interference signals, this switchable, 24-filter filterbank frees up defensive system resources for processing, declaring or countering hostile emitters.

Background

Aircrew situational awareness of the combat environment in future battlefields will significantly impact survivability. Electronic warfare (EW) systems must be able to "strip out" interfering signals from an environment that is saturated with radar, communication and other electronic transmissions. Current EW systems use slow turning yttrium iron garnet (YIG) microwave filters. Advanced frequency agile emitters with fast hop rate capability are now being used in radar and communication systems for electronic counter-countermeasure purposes, providing detection avoidance, jam resistance and counter anti-radiation missile capabilities. Signals from these emitters pose a problem for YIG filters. Superconductor Technology's filterbank, arguably the most complex microwave HTS subsystem ever developed, effectively frees up the limited signal and data processing capabilities of the defensive system, allowing it to find hostile signals that may have been masked previously by interfering signals. To measure its effectiveness, engineers used a digital simulation model to analyze survivability estimates for a three bomber formation and for fighter missions. For the bomber formation, the maximum survivability improvement was estimated to be 30 percent. The maximum survivability improvement for the fighter mission scenarios analyzed ranged between 25 percent and 55 percent.



CHAFF SIGNATURE MEASUREMENT SYSTEM INCREASES DoD AND NATO AIRCRAFT SURVIVABILITY

Payoff

The gathering of previously nonexistent chaff signature data by Wright Laboratory during in-flight test scenarios will increase the survivability of DoD and NATO aircraft in a combat environment. The data collected using the "chaff processor," shown left, will be used to modernize chaff dispensing and defensive maneuvers.

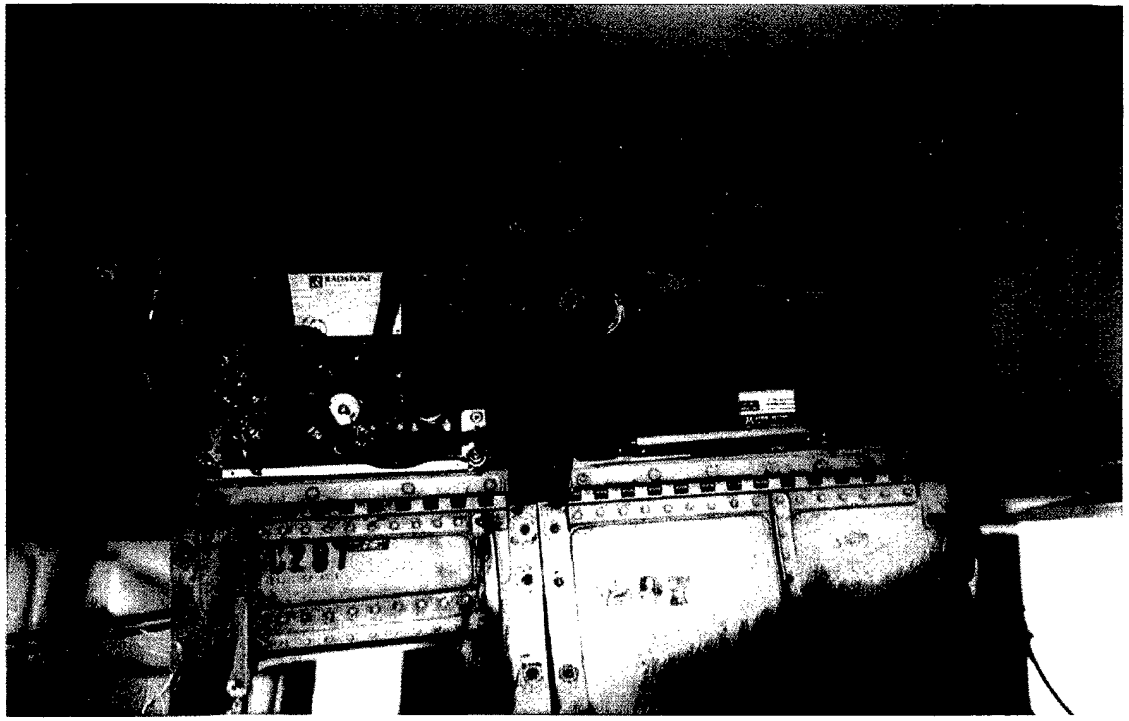
Accomplishment

Scientists in the Avionics Directorate's Radio Frequency Technology Division developed a data acquisition and analysis system to evaluate chaff and decoy performance during in-flight test scenarios. This system, dubbed the "chaff processor," was the first such hardware to collect usable chaff Doppler data and allow for real-time determination of chaff and decoy radar cross sections and Doppler signatures as they are dispensed from an aircraft.

Background

Chaff, as the most commonly used radar countermeasure since World War II, is used by almost all military aircraft. Unfortunately, its poor Doppler performance makes it less effective against the new generation of coherent radars. However, flight tests still demonstrate that chaff can cause modern radars to break "lock" if it is used with a proper maneuver and combined countermeasures. Historically, researchers have not been able to obtain the radar cross-section and Doppler data for chaff during the very early dispensing stage. This stage is the most critical moment in determining chaff effectiveness. The new data gathering approach developed by the Directorate uses time and frequency domain analysis plus data manipulation techniques to remove both the aircraft's signature from the chaff and its mixed signal. The processor interfaces directly to a coherent radar. Both the in-phase and quadrature video signals are processed in frequency domain to remove the aircraft signature and get chaff Doppler data. This technology was used in a NATO series of operational and research and development flight tests called TRIAL MACE VIII, to provide the data required to determine chaff and combined countermeasures effectiveness and requirements for success against various radar threats.


TRW



New Data Collection System Improves Supportability and Maintainability of Avionics Software

Payoff

The ability of the Data Integration and Collection Environment (DICE) system to collect and record operational radar data will aid system analysts in the analysis of avionics embedded computer system's software degraded performance and operation. By enhancing the rapid reprogramming process of embedded computer systems software, the turnaround time required to accomplish a fix will be reduced through the reduction of labor hours and test missions. For example, the ability of the DICE system to collect and record operational data in support of the F-15 APG-63 radar will result in an estimated cost savings of $2.2 million over a 15 year period.

Accomplishment

Under a program sponsored by the Avionics Directorate's Systems Avionics Division, TRW developed a low-cost, on-board data collection system that was transitioned by the Directorate to Nellis AFB NV for use in the operational environment of an F-15C aircraft. Utilizing the F-15 APG-63 radar system as a proof-of-concept, this DICE system demonstrated the capability to collect and record the anomalous mission event(s) data which led to the radar system's degradation.

Background

Avionics embedded computer systems (ECS) and its software provide a high level of flexibility in both system configuration and capability. However, increased flexibility requires increased logistical support in relation to emergency and update changes of the ECS software. The objective to improve the supportability and maintainability of avionics mission critical software is paramount in meeting the timeliness of emergency changes. In order to effectively achieve rapid turnaround of ECS software changes, the data processed during a mission anomaly must be provided to the operational flight program (OFP) maintainer for mission re-creation to ensure appropriate changes are made to the OFP. Rapid turnaround is defined as correcting a system deficiency in a timely manner through some combination of software, firmware, and/or hardware modifications. The current method used by Warner Robins Air Logistics Center to maintain F-15 APG-63 OFP software relies mainly on a pilot's written description of the anomalous behavior occurring in flight. The DICE system improves the efficiency of this process by providing accurately recorded flight data to the OFP maintainers which can later be used to re-create the software anomalies.

Quick Solution Enables Safe Deployment of C-17 Aircraft to Bosnia

Payoff

The Fuels and Lubrication Division, of the Aero Propulsion and Power Directorate, provided a solution to an operational problem that was instrumental in ensuring the safe deployment of C-17 aircraft to Bosnia in December 1995. The Directorate's timely analysis of a problem involving a series of lubricant-related failures of the integrated drive generators (IDGs) on the F117 engine of several C-17 aircraft, enabled the Air Force to deploy the aircraft on schedule to Bosnia in support of the peacekeeping mission.

Accomplishment

Working under a deadline of less than one week, the Aero Propulsion and Power Directorate provided the C-17 System Program Office (SPO) information on the cause and prevention of potentially catastrophic lubricant related failures of the IDGs on the F117 engines of several C-17 aircraft. From samples provided by the SPO, Directorate scientists determined that the oil was reacting with the magnesium alloy housing of the IDG in the presence of water (probably from high humidity) to form a magnesium carboxylate soap. This soap clogged oil lines and filters, causing lubricant starvation and eventual mechanical system failure within the IDG. The C-17 IDGs were put on a short period (50 hour) oil change schedule and instructions were issued to maintenance crews to monitor the oil closely for the soapy material.

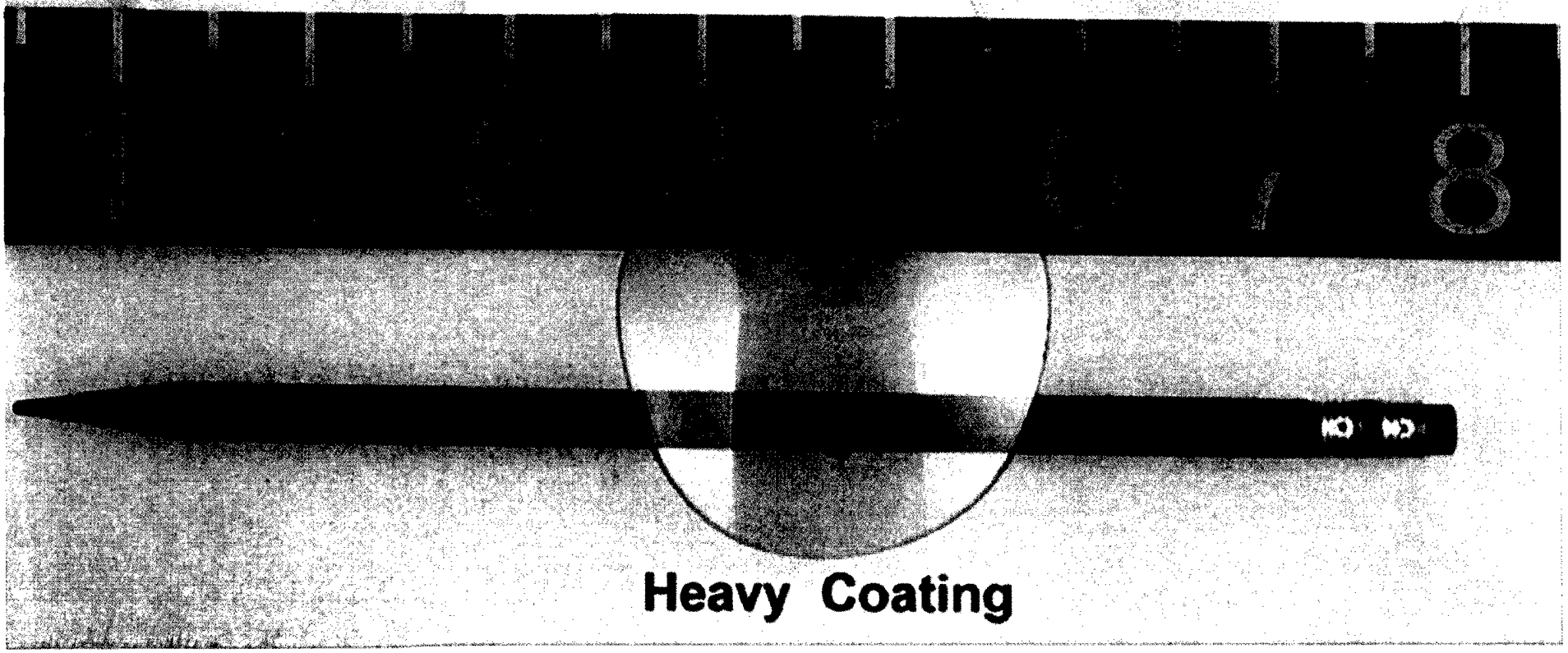
Background

It has been known for at least 40 years that a detrimental chemical reaction between magnesium and ester oils will take place in the presence of high levels (<1,000 to 2,000 parts per million) of water at typical turbine engine operational temperatures (>300°F). For this reason, the Air Force has strictly controlled or prohibited magnesium containing components from coming in contact with the polyol ester oils, which are used in most turbine engines and turbomachinery world-wide. A few turbomachinery component manufacturers still insist on using magnesium components in oil-wetted systems, despite the knowledge of potentially dire consequences. Fortunately, the level of water in most turbine oil systems does not rise above 1,000 parts per million, under normal circumstances, thereby somewhat alleviating the problem of magnesium-oil reaction. The lower water concentration is typical because most systems are vented to the atmosphere, allowing water to be evaporated out of the system. The current C-17 IDG, however, is essentially a closed system with one valve on the IDG that will occasionally actuate to allow air into the IDG. If humid air enters, moisture is trapped which can lead to the formation of the magnesium soap and eventual failure of the IDG.

No Coating

Light Coating

Wright Laboratory
Aero Propulsion and Power Directorate
Aerospace Power Division



Heavy Coating

Ion Beam Diamond-Like Carbon Coating Process Provides Low Cost, Durable Coatings

Payoff

The ion beam diamond-like carbon (DLC) coating process enables low cost, abrasion resistant and chemically/biochemically inert coatings to be applied to a variety of surfaces. This process, using nontoxic materials, can produce protective coatings with a wide variety of thickness and optical transmissivity which can be designed to meet a large number of military and commercial user needs.

Accomplishment

The ion beam DLC coating process, developed under a program sponsored by the Aero Propulsion and Power Directorate's Aerospace Power Division, produces low cost, durable, high quality coatings which are free of pin holes, have excellent transmissivity and excellent adhesion to a number of different types of surfaces. An ion beam applied DLC coating can endure a wide range of environmental conditions such as temperatures up to 500 degrees F, abrasion and interaction with chemicals/biochemical/gaseous agents.

Background

Although the ion beam DLC coating process is one of a number of techniques for deposition of DLC that have evolved, it is unique. It is a low temperature coating process utilizing low energy plasma that does not adversely affect the substrate. Products exhibit very low surface friction, excellent glare reduction, ultraviolet filtering and good infrared (IR) transmissivity. Flat and moderately curved surfaces can be handled up to a diameter of 8.5 inches (1000 square centimeters) using current equipment. This technology, developed and demonstrated under contracts with Universal Energy Systems and K-Systems, has a large number of military and commercial applications. Potential applications for ion beam DLC protective coatings include aircraft transparencies, automotive windows, eye glasses, food packaging equipment, electronic components, IR imaging system optical windows, computer hard drives, cutting tools and body implants. A Cooperative Research and Development Agreement, executed by the Aero Propulsion and Power Directorate with nanoFILM LTD, has demonstrated an eye glasses coating with excellent results. This technology has been validated under the Aeronautical System Center's Senior Assessment Review process.

IMPROVED AIRCRAFT TRANSPARENCY REPAIR DEVELOPED

Payoff

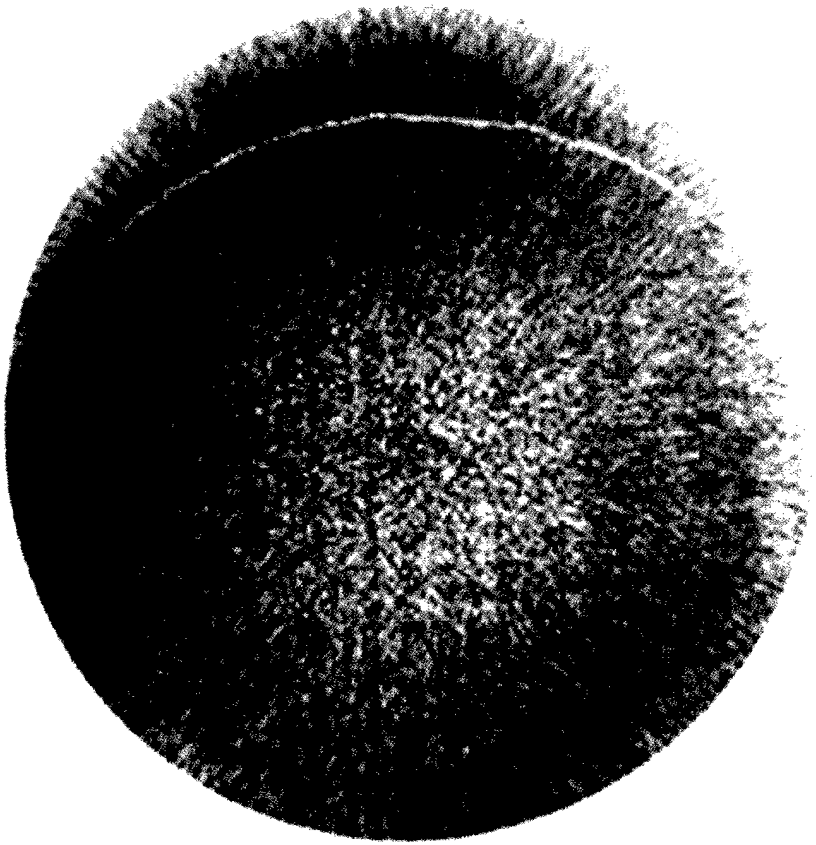
Identified and developed through the international Four Powers Aircraft Battle Damage Repair (ABDR) Working Group, the improved transparency repair method will improve combat mission readiness for its four allied member nations and save dollars through shared development teamwork. The repair technique has been tested and validated for all typical Air Force transparency types.

Accomplishment

Through the combined efforts of the Flight Dynamics and Materials Directorates, and under the auspices of an international working group, an ultraviolet (UV) curing methacrylate adhesive to fill the damaged area of an aircraft transparency was identified and tested. This adhesive material, which can be polished to a transparent finish, exhibits excellent mechanical properties and cures in a matter of minutes at any ambient temperature when exposed to UV light.

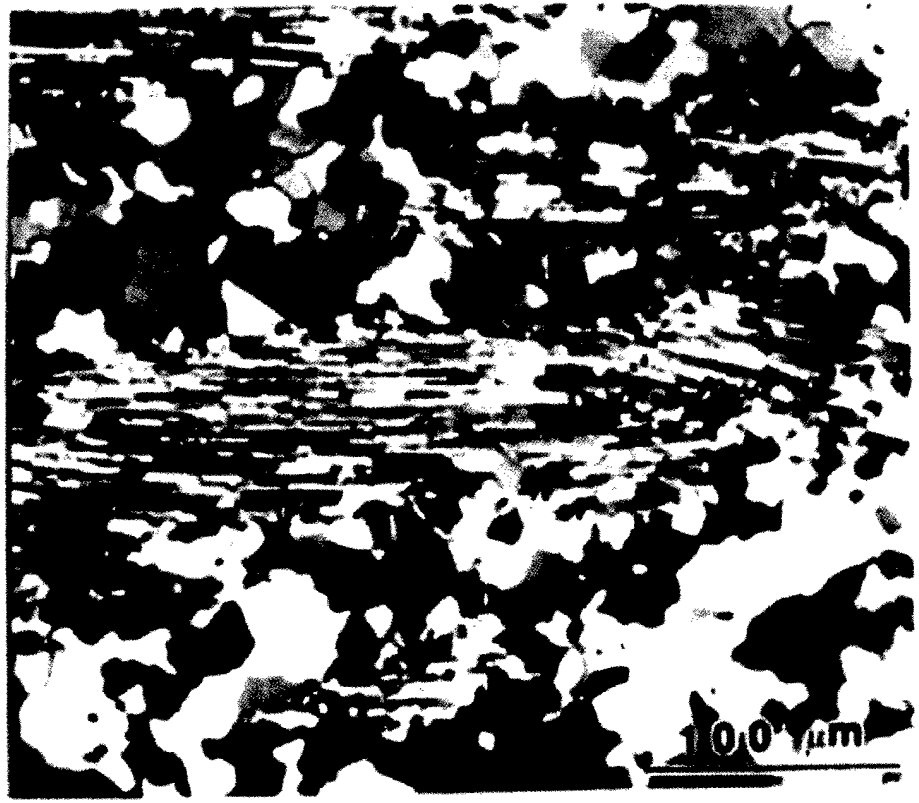
Background

Personnel from the Flight Dynamics and Material Directorates participate on the Four Power ABDR Working Group which includes representatives from France, the Federal Republic of Germany and the United Kingdom. The purpose of the group is to develop and exchange generic ABDR techniques, procedures and methodologies that will enhance the ABDR capability of each nation individually and collectively in terms of ease, effectiveness, time, material and resources. The current ABDR technique for transparencies is common to all four nations. It involves attachment of a metallic patch using threaded fasteners and sealing the area with a two-part room temperature curing sealant. Although this repair technique is quick and effective for allowing more combat sorties, the repair greatly restricts pilot vision. The adhesive identified by Wright Laboratory dramatically improves the visual quality of the damaged area without increasing the current repair time for a battle damaged transparency.



50 mm

INTERNAL CRACKING OF INGOT



MICROSTRUCTURE SEGREGATION

Improved Processing Methods for Gamma Titanium Aluminide Alloy Ingots Offer Potential for Lighter Engines

Payoff

Advances in the knowledge, understanding and control of gamma titanium aluminide alloys will overcome problems of brittleness and cracking during ingot manufacture and microstructure segregation during ingot cooling. Precise control of specific alloy properties will result in materials for gas turbine engines capable of operating at temperatures up to 300°C hotter than conventional alloys while reducing engine weight by as much as 550 pounds.

Accomplishment

Scientists in the Materials Directorate's Metals and Ceramics Division developed processing methods to improve room-temperature ductility and fracture toughness in gamma titanium aluminide alloys while maintaining the materials' outstanding high-temperature performance. This included an ingot fracture model that analyzes the casting process and pinpoints the processing conditions required to obtain sound, defect-free aluminide ingots and special heat treatment cycles to produce a controlled homogeneous material microstructure with desirable properties that would carry into the end product.

Background

Nickel-based superalloys, used in gas turbine engines to withstand high operating temperatures, have made the gas turbine engine one of the heaviest aircraft components. A material family that would reduce engine weight is gamma titanium aluminide alloys. These intermetallic materials possess a balance of low density, excellent stiffness and strength and outstanding operational capability at high temperatures. First investigated in the 1950's, the gamma aluminide's promise of high performance at high temperatures was overshadowed by brittleness; i.e., very poor ductility and low fracture toughness at room temperature. Initial attempts to improve performance for these critical properties by alloy modification met with limited success. To improve room-temperature ductility and fracture toughness in the gamma aluminides while maintaining its outstanding high-temperature performance, Directorate scientists had to overcome several obstacles. One was the problem of cracking in large ingots due to thermal stresses induced by temperature non-uniformities during casting and cooling. After gaining an understanding of the failure mechanism during ingot solidification and cool down, they developed an ingot fracture model, to obtain sound, defect-free aluminide ingots. Yet even when they were crack-free, aluminide ingots often contained nonuniform microstructures which persisted through subsequent metalworking operations. Investigations revealed two-phase microstructures which often became segregated when the ingots cooled, making it difficult to achieve control of performance properties in end products. The special heat treatment cycles that were developed to solve this problem produced a controlled, homogeneous microstructure in the material which carries through into end products with repeatable, desirable properties.

Wright Laboratory Contracting Directorate Receives 1995 Unit Awards for Improved Business Processes

Payoff

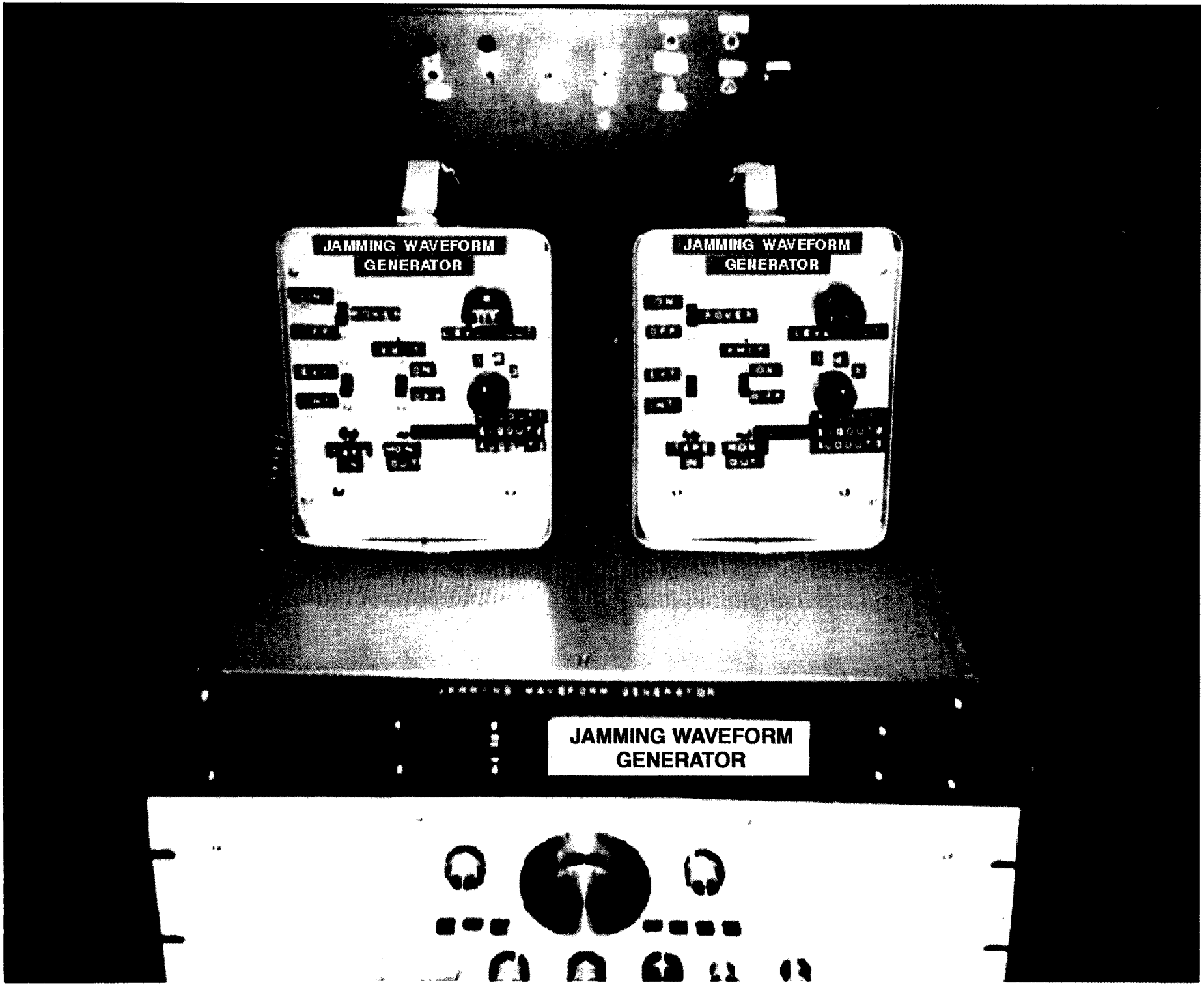
The improved acquisition business processes, developed by Wright Laboratory's Research and Development Contracting Directorate, have resulted in streamlined solicitations, more efficient source selections and better communications with customers. The Directorate is a role model in the acquisition reduction process that will form the basis for the new acquisition environment.

Accomplishment

For the second time in four years, Wright Laboratory's Research and Development Contracting Directorate received both the Air Force Materiel Command (AFMC) Outstanding Contract Unit Award and the Air Force Outstanding Unit Award for Systems or Science and Technology Contracting. The Directorate was recognized for its mission accomplishment, management of available resources and adherence to regulations and directives.

Background

When Acting Assistant Secretary of the Air Force for Acquisition, Darlene Druyun, announced on 31 May 1995 Lightning Bolt Initiatives designed to reform acquisition policies, Wright Laboratory's Research and Development Contracting Directorate was already immersed in developing improved acquisition business practices and applying them to science and technology efforts. The Directorate reduced average procurement award times to 50-75 percent of the AFMC standard; pioneered command use of procurement assistance instruments and employed them to implement laboratory programs that were not feasible to initiate with contracts; led a DoD implementation of the Research and Development Streamlined Contracting Procedures Program; used an integrated acquisition approach in support of a national priority program and instituted an enhancement to industry communications via a Home Page on the World Wide Web. In addition, the Directorate created a rapid response Program Research and Development Announcement/Broad Agency Announcement acquisition process for high priority Laboratory requirements that demonstrated a two-thirds reduction from acquisition cycle time standards. The Directorate's accomplishments enhanced their ability to play a leadership role in developing a new Science and Technology Source Selection regulation, develop an innovative automated contract writing program and publish new guides that help facilitate improved business processes.


JAMMING WAVEFORM GENERATOR
JAMMING WAVEFORM GENERATOR
JAMMING WAVEFORM GENERATOR

Quick Reaction Provides Critical Equipment for US Space Command

Payoff

Quick response by Avionics Directorate engineers provided the US Space Command with critically needed waveform generators for a major Multi-Service Joint Task Force Exercise. The generators, developed in-house for $15,000, were key components that provided valuable information regarding space communications protection and confirmed the Command's specific defensive counterspace concept during the exercise. The Command is using the generators for other on-going training missions.

Accomplishment

Quick reaction support provided by scientists at the Avionics Directorate helped the US Space Command validate one aspect of their defensive counterspace electronic protection concept during a major Multi-Service Joint Task Force Exercise. Within four months, the Directorate's scientists designed and developed a set of field deployable, live electronic jamming signal field training generators that were successfully integrated with the Command's radio system.

Background

The defensive counterspace electronic protection concept includes protective measures that insure military equipment and personnel are effective in the presence of hostile force activities directed against US exoatmospheric electronic systems. The Directorate's scientists had only four months to develop the set of electronic attack generators before the start of a major Joint Task Force Atlantic Command Exercise. One prototype jamming waveform generator, a portable system and two final versions of the electronic attack waveform generators were developed. In addition to the design and development of this equipment, they had to evaluate the design and electronic circuitry of a complex militarized Space Command radio system for use as the primary radio frequency electromagnetic signal source. A low-end approach was developed with off-the-shelf commercial electronic components used in the assembly of the waveform generators. The generators, which interfaced with existing radio circuits, modulate a low frequency signal and is up-converted to an ultra-high radio frequency for transmission from a portable high gain antenna. Tests were conducted in an Avionics Directorate facility prior to the Atlantic field test deployment. Critical information, regarding space communications and countermeasures, focusing on approaches to defensive counterspace techniques, was obtained. In addition to achieving the basic objective of developing the set of electronic attack waveform generators for use in the training mission, an operations manual for the field technicians was produced.

Fiber Metal Laminate Composite Repair Patch Stops Crack Propagation

Payoff

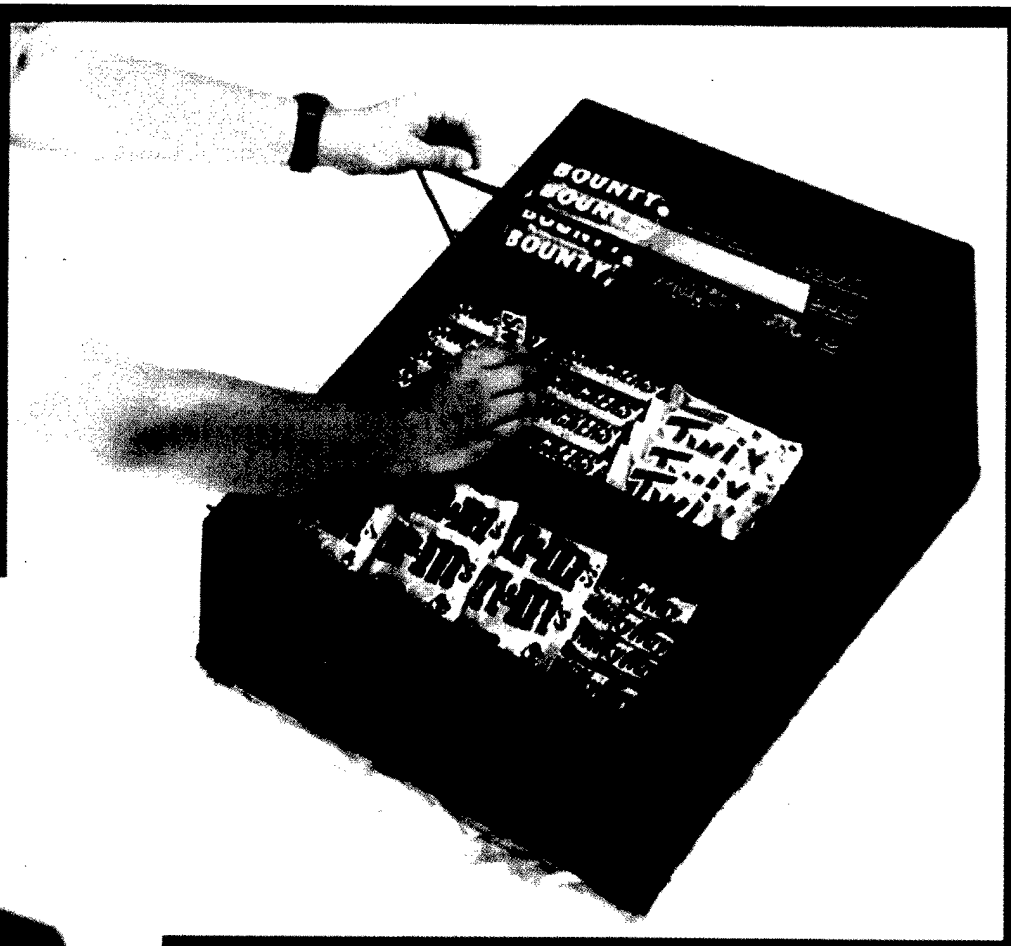
The application of adhesively bonded fiber metal laminate composite repairs to the C-5A's aft upper crown fuselage skin will improve repair efficiency and resistance to crack propagation. Repairing individual cracks in the crown skin of a C-5A cargo aircraft instead of replacing the entire skin panel could result in significant cost avoidance over the life of the fleet.

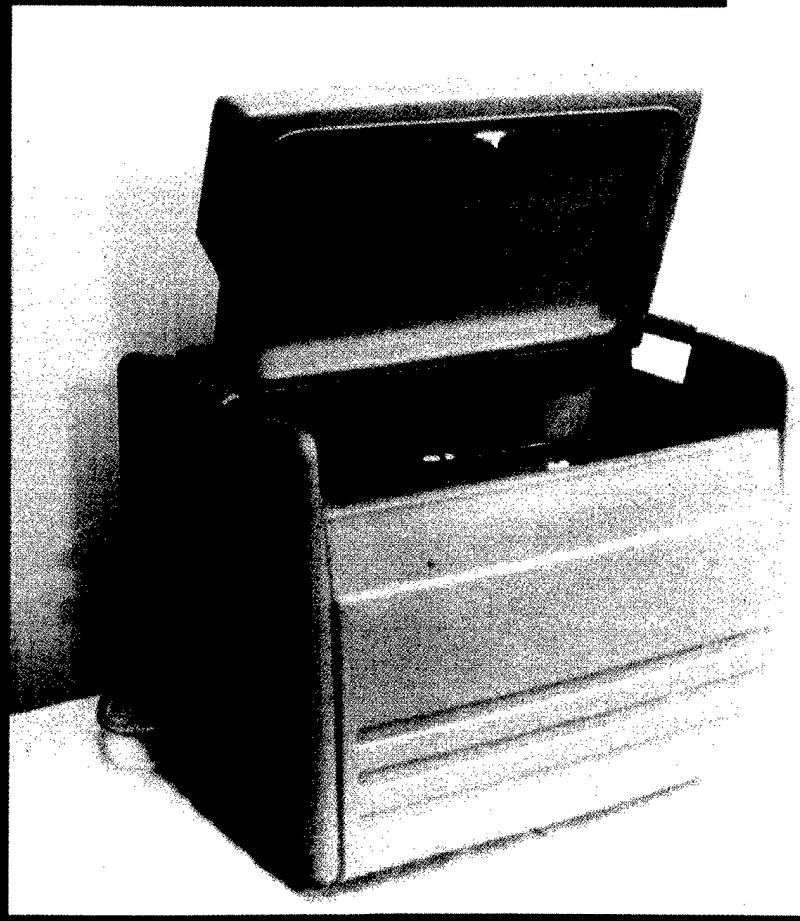
Accomplishment

A new fiber metal laminate composite, employed as a repair patch on the aluminum skin of a C-5A transport aircraft, was subjected to over 25 hours of flight tests with 29 landings, 10 full stops and 32 landing gear cycles. Crack growth inspections conducted by a team of engineers from the Flight Dynamics Directorate's Structures Division, the Air Force Academy (AFA) and the San Antonio Air Logistics Centers (SA-ALC) indicated no voids in the bondline of the patch and no crack growth outside the tolerances of the inspection probe.

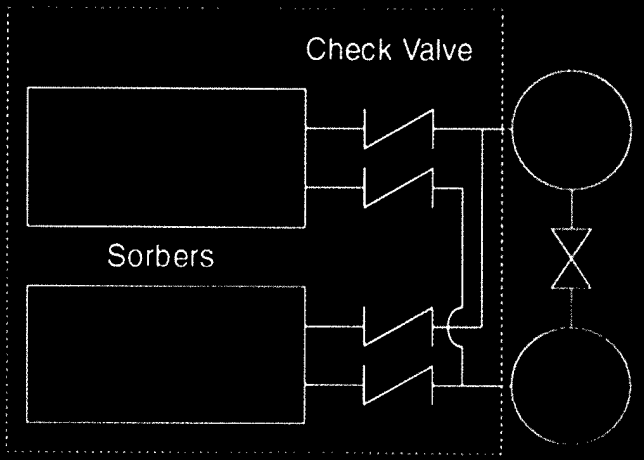
Background

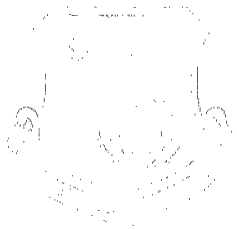
Aging aircraft, such as the C-5A transport aircraft, are facing earlier than anticipated retirement if current structural repair technology is not improved. Traditional methods involve costly replacement of structure or installation of mechanically fastened metallic patches. The installation of metallic patches introduces additional sites for damage initiation due to the drilling of numerous fastener holes. While traditional methods possess many advantages, such as quickness and ease of installation, they can significantly reduce fatigue life if insufficient design and strength analysis are performed. The crown skins of the entire fleet of C-5A's have been plagued with fatigue cracks and the rivited metallic repairs have not been successful in stopping crack propagation. To counter the disadvantage of riveted repairs, adhesively bonded metallic repairs can be used to improve the repair's efficiency and fatigue resistance. In October 1995, a team of engineers from the Flight Dynamics and Materials Directorates, AFA, SA-ALC and Delft University in the Netherlands, repaired two cracks on a C-5A which had been detected during preventive depot maintenance at the ALC.





Replaces Compressor on Conventional System





Electronics Cooling Technology Has Dual Use Applications

Payoff

Technology employed in the design of a new adsorption-based refrigeration system to cool high heat flux electronics in electronically intensive aircraft and mobile military vehicles has spun-off into the development of several commercial product prototypes. This has included a point-of-sale candy bar freezer, a hotel room refrigerator/freezer and a portable freezer.

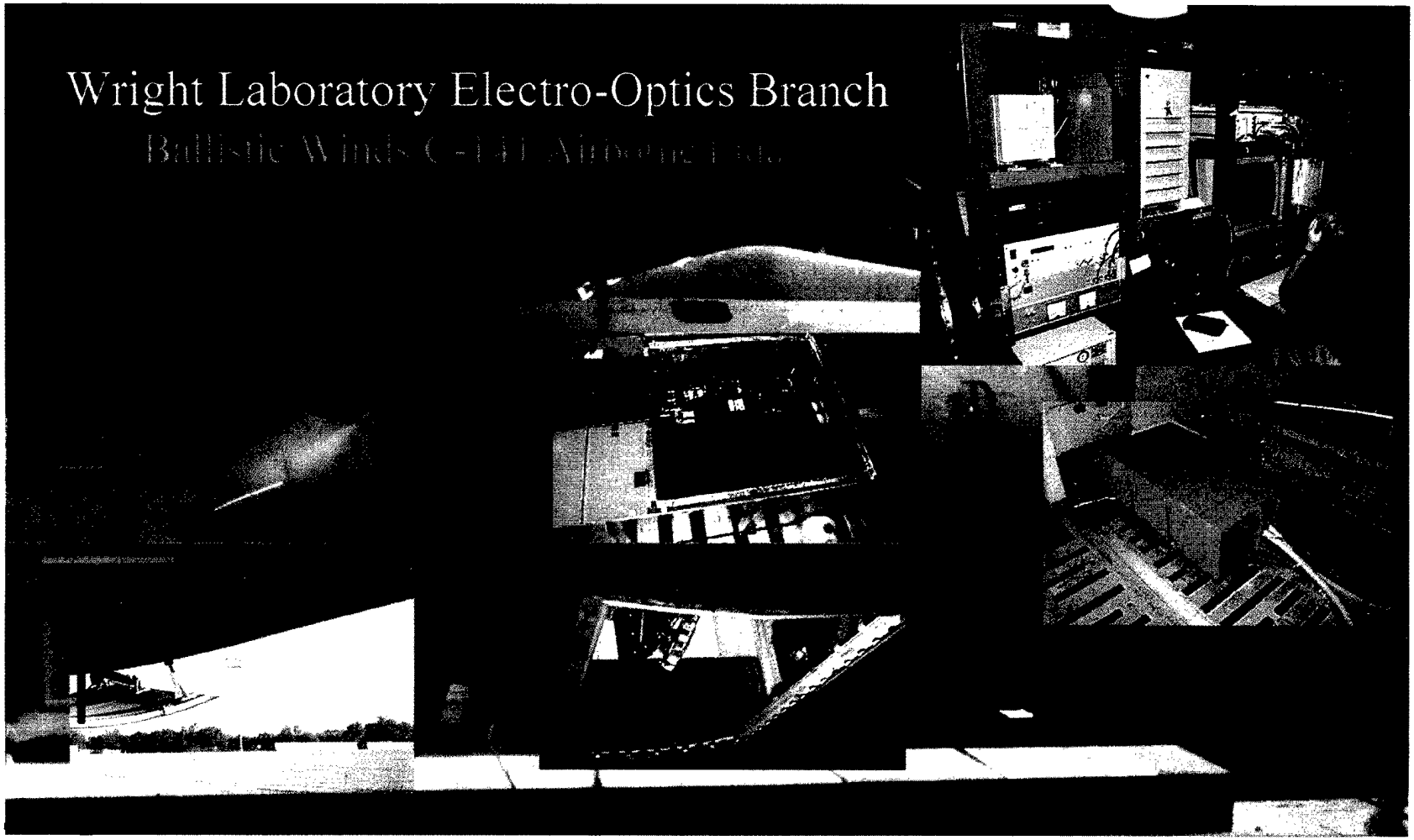
Additional potential commercial applications of the technology include utilization of an adsorption heating and cooling system to increase the range of electric vehicles and reducing auto emissions through catalytic converter preheating on conventional vehicles.

Accomplishment

Under a program sponsored by the Aero Propulsion and Power Directorate's Aerospace Power Division, Rocky Research Inc. developed an adsorption-based refrigeration system that works off the heats of adsorption and desorption of ammonia and a solid salt. It can be scaled down to sizes that are appropriate for portable military and commercial applications without any loss in efficiency.

Background

The miniaturization of conventional vapor-compression refrigeration systems is limited by the tolerances that can be reasonably obtained in the manufacture of the compressors or pumps. In contrast, the new adsorption refrigeration system has no compressor or other moving parts and thus has no critical machining tolerances that inhibit it from being scaled down in size. Its operation is similar to natural gas powered *ab*sorption refrigerators that work off the heats of *ab*sorption and desorption of two liquid constituents that are typically ammonia and water or lithium bromide and water. However, it is the difference in constituents used in the Rocky Research system that makes it more appropriate for aircraft applications where variable orientations to ground would cause undesired migration of fluids. Since this refrigeration system may be powered by heat energy as well as primary electrical power, aircraft engine exhaust heat could be used to operate the device. Another advantage of adsorption refrigeration systems is their inherent storage capability. This capability enables this type of system to be started instantaneously and operated for a period of time without any energy input. It is a feature that is especially attractive for chemical warfare suit cooling and electric vehicle heating and air conditioning.


Wright Laboratory Electro-Optics Branch

Laser Radar-Based Wind Information System Improves Target Zone Accuracy

Payoff

Using the laser radar-based system to obtain real-time, ground-level wind information will greatly enhance a pilot's ability to place ordnance, cargo and personnel more precisely on target while flying at higher, safer altitudes. Shown above is the Airdrop Ballistic Winds program version and associated Laser Detection and Ranging equipment. Further development of the system will help improve wind shear detection for both military and commercial aircraft.

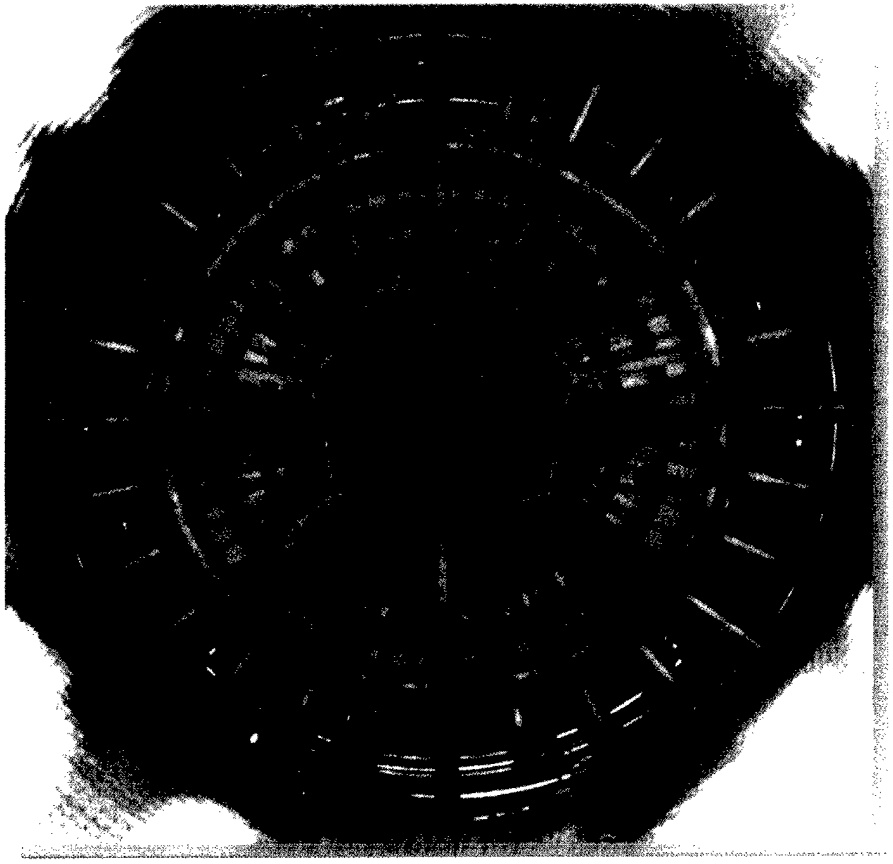
Accomplishment

Scientists at the Avionics Directorate developed a Laser Detection and Ranging (LIDAR) wind information system that provides pilots with accurate, real-time ground wind speed and direction in a target area or drop zone from as far up as 40,000 feet. It provides 3-dimensional wind information from altitude to ground with range slices of hundreds of meters and velocity accuracy to within 0.5 meters per second.

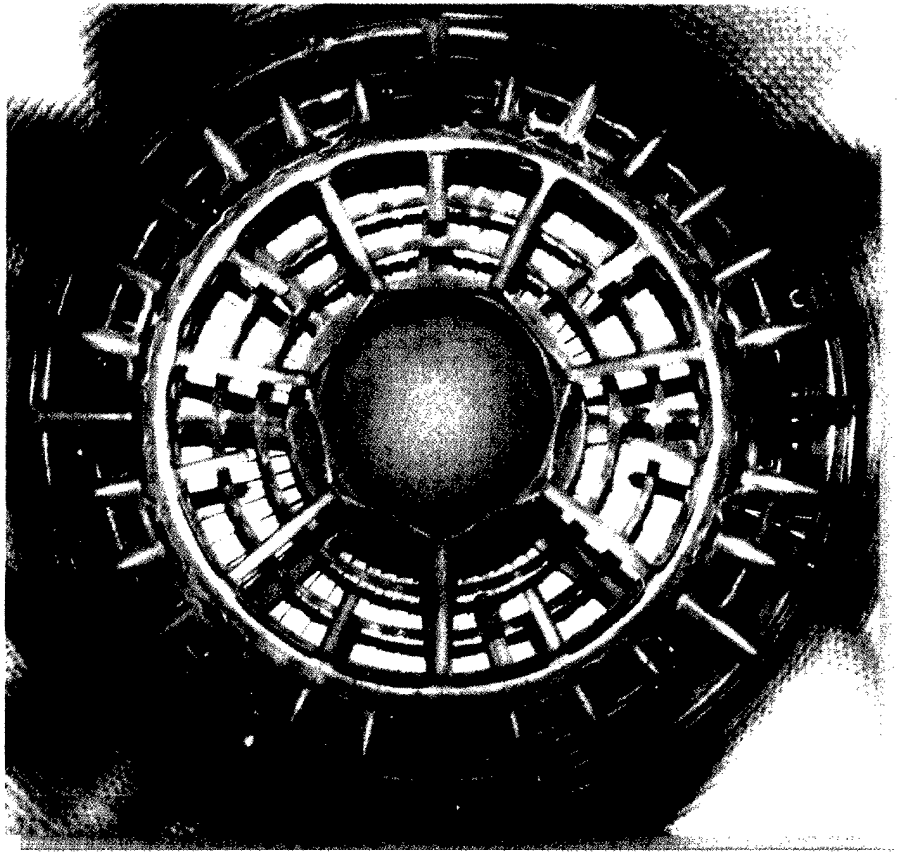
Background

During cargo missions, pilots sometimes miss the drop zone by up to a mile because they do not have accurate wind data from the target area of the drop zone. Combat air crews experience the same problem in delivering ordnance. Flying low enough over the drop zone or target area to gather accurate wind information could endanger aircrews and jeopardize mission completion. Currently, cargo aircraft fly at around 1,200 feet for an accurate air drop, well within range of enemy ground fire and surface-to-air missiles. Special Operations gunships crews have to fly into the target area at a low speed and altitude and fire several test shots to calculate wind affect on their ordnance. After compensating for the wind conditions, they commence firing at the target while continuing to orbit the target area at a low speed and altitude. One wind measurement system, demonstrated on a C-141 cargo aircraft, uses a 2-micron laser source which shoots a laser pulse from the aircraft through the atmosphere. Laser light reflected back to sensors on the aircraft from dirt and water particles moving with the wind are analyzed with conical laser scans to determine directional information. The short pulse length of the laser provides range slices of the atmosphere. The Flight Dynamics Directorate's Global Positioning System-based Dropsonde Atmospheric Profiling System and Phillips Laboratory's ground based LIDAR system have been employed during flight tests of the Avionics Directorate's LIDAR system both as backup systems and sources of additional data. Engineers at the Phillips Laboratory facility at Hanscom AFB MA are focusing on using the technology to improve B-52 bombing accuracy. They have performed several experiments to quantify expected performance gain of the aircraft by having an airborne wind profiler. Their tests have shown improved bomb drop accuracy even from above 40,000 feet. A LIDAR equipped B-52 will effectively make general purpose bombs more like precision weapons.

- 200+ Hours on JP-8



- 200+ Hours on JP-8 then 56 Hours on JP-8+100



JP-8+100 Fuel Technology Transitioned

Payoff

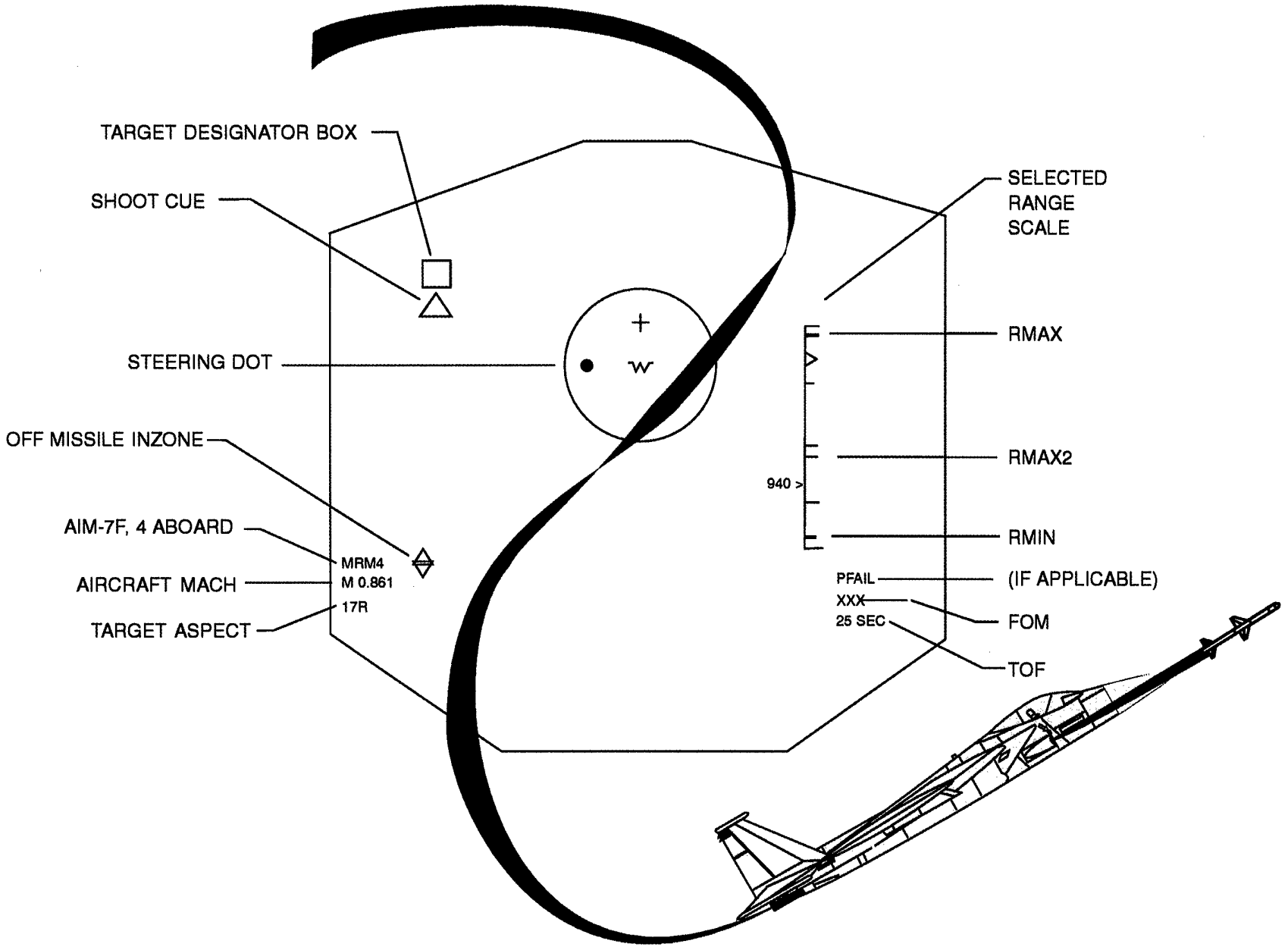
JP-8+100 is improved JP-8 fuel with a "fuel injector cleaner" (additive) that reduces fouling/coking in engine fuel controls, mainburner fuel nozzles, manifolds and augmentor sprayrings/ spraybars and reduces smoke and soot in older engines. JP-8+100 will reduce engine and aircraft fuel system operation and maintenance costs for current and future aircraft. To initiate its transition, the JP-8 specification (MIL-T-83133D) was amended to allow limited use of the additive with approval for planned fleet-wide use in fiscal year 1998.

Accomplishment

The Fuels Branch of the Aero Propulsion and Power Directorate led a government/industry/academia team in the development and demonstration of additives that improve thermal stability in JP-8 fuel. These "fuel injector cleaner" type additives increase the thermal stability of JP-8 by 100°F (from 325°F to 425°F) and significantly reduce fuel fouling and coking.

Background

Fuel is the primary coolant for engine and aircraft subsystems. In many current high performance engines, fuel is heated to temperatures above 325°F, the thermal stability limit of JP-8. When the thermal stability limit is exceeded, the fuel breaks down into gums, varnishes and carbon deposits (coke). These deposits cause degraded performance in engine fuel controls, fuel nozzles, and augmentor sprayrings/spraybars. When fuel nozzles or augmentor sprayrings/spraybars coke, combustion spray patterns are distorted and acustic resonances that can lead to high cycle fatigue are created. The additives were tested in-house in over 1000 hours of ground engine tests and flight tested by the 416th Flight Test Squadron at Edwards AFB in September 1994. An F-16A with an F100-PW-200E engine was piloted through dry power and augmentor transients, primary and secondary fuel control transfers and 28 air starts. With the success of the flight test, a base demonstration was initiated with the Air National Guard (ANG) at Kingsley Field OR. Nineteen F-16A/B aircraft with F100-PW-200 engines have flown over 3000 hours and demonstrated a significant reduction in engine maintenance costs with JP-8+100. The improved fuel has increased the mean time between fuel related engine anomalies by 340 percent. Fuel system maintenance costs have been reduced from $374 per flight hour with JP-8 to $106 per flight hour with JP-8+100. Maintenance manhours have been reduced from 45 minutes/flight hour with JP-8 to 12 minutes/flight hour with JP-8+100. The ANG unit at Kingsley Field documented maintenance savings in excess of $825,000 in fiscal year 1995. The Air Education and Training Command is also supporting a base demonstration of JP-8+100 in T-37/T-38 aircraft at Sheppard AFB TX. The aircraft have flown over 2500 flight hours and have demonstrated dramatic reductions in fouling/ coking and smoke. Based on extrapolation of the data obtained, the Air Force could have a cost avoidance of as much as $80 million/year in maintenance.


TARGET DESIGNATOR BOX
SHOOT CUE
STEERING DOT
OFF MISSILE INZONE
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Updated Algorithm Technology Improves F-15 Missile Launch Capability

Payoff

The updated algorithm for the F-15 aircraft's missile launch control system will enable pilots to more accurately predict, before they fire a missile, if it will hit its target. Increased air-to-air missile launch successes will increase pilot and aircraft survivability in a combat environment.

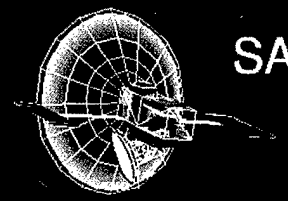
Accomplishment

Under a program sponsored by the Avionics Directorate, First Ann Arbor Corporation updated algorithm technology for employment into the missile launch envelop software of the F-15 aircraft computer. The accuracy of air-to-air missiles fired from F-15 aircraft is improved through the modification and application of a software program originally developed in the 1970s to solve deficiencies like those in the F-4 aircraft computer.

Background

In the late 1970s, the F-4 aircraft's missile launching control system experienced problems in accurately following a target when it was performing evasive maneuvers. The pilot's computer would display erroneous readouts on the vulnerability of the target causing failed missile launches. The missile launch envelope is a computation on whether an aircraft is within launch parameters of the missile against a given target. During the 1970s newer powerful digital computers, with enough processing power to accept advanced algorithm technology, were being installed into fighter aircraft such as the F-16. This presented an excellent opportunity to develop new algorithms that had superior calculating properties and took advantage of improved digital technology. In parallel with the development of newer computers, General Dynamics of Ft Worth TX was developing algorithms for missile launch envelope software in the F-16 aircraft. Called velocity simulation (VSIM), it was immediately incorporated into the F-16. The F-15 computer did not have the calculating throughput to accept new algorithms with superior calculating properties until a new chip was installed in the 1990s. This computer upgrade enabled engineers, when converting old assembly language in the F-15 operational flight program, to examine many different ways to make software improvements. One of the most important improvements was resurfacing the Avionics Directorate's F-15 missile launch software program, making algorithm modifications and installing the updated software program into the F-15 computer.

EXPERT COMMUNICATIONS LINK MANAGER (ECLM) DEMONSTRATED



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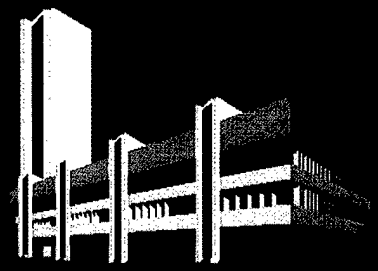

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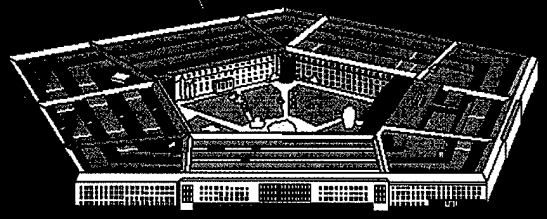


COMMAND POST

ENROUTE CONTROL

EXPERT COMMUNICATIONS LINK MANAGER (ECLM) DEMONSTRATED

Payoff

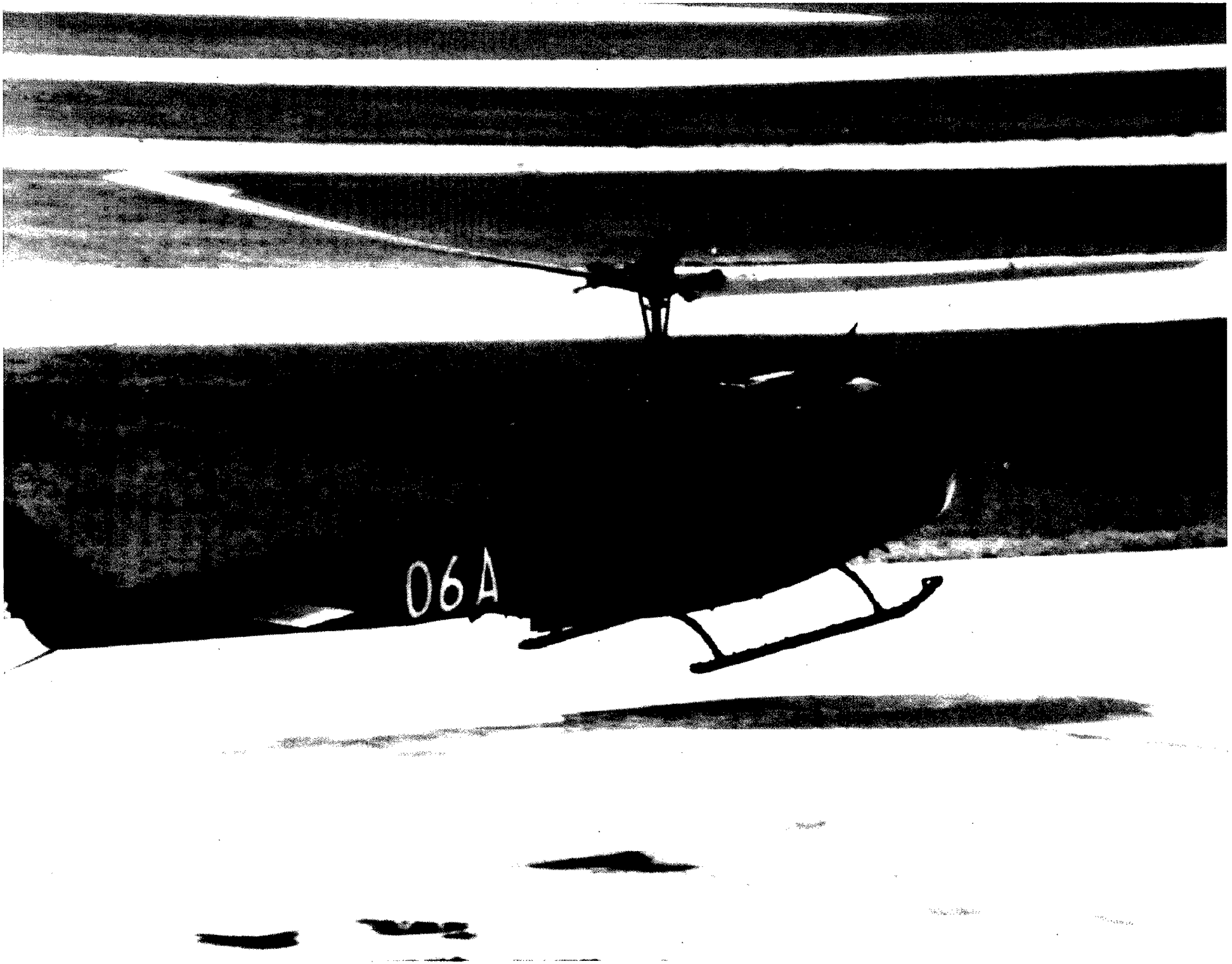
The ECLM is a bench top system that demonstrates how an expert system, using voice input, can control the communications suite of an aircraft and significantly improve pilot operational effectiveness. It will enable a pilot of an aircraft to use voice commands to control communication resources in a way not currently possible, thereby reducing pilot workload.

Accomplishment

The Avionics Directorate's Information Transmission Branch developed and demonstrated the first expert system that uses voice input to control the communications suite of an aircraft. This ECLM bench top system is combined with a voice-based system to make the decision of which system elements, i.e. a radio, to use based on position, beyond line-of-sight, resources available, etc.

Background

With the flight deck of the modern aircraft becoming crowded with an increasing number of navigation, identification and communication equipment, the work load on the pilot is ever increasing, therefore, decreasing mission effectiveness. The Information Transmission Branch saw an opportunity to decrease pilot workload and increase operational effectiveness by exploring the use of an expert system with voice input to determine the optimal communication method, allocate communication resources and tune the system to the optimal frequency. A voice-based system is used to keep the pilot's eyes out of the flight deck and on the target and an expert system is added to free the pilot from making the decision as to what system and/or frequency to use. After the expert system receives the oral command, it takes position, attitude, analysis of the mission environment, resources available, etc., into account, accesses a knowledge base and configures the appropriate systems to the correct frequency. Voice feedback is then used to verify the actions to the pilot. The ECLM automatically switches the pilot to the desired radio, however, the pilot always maintains manual override capability. The bench top system employed commercial off-the-shelf equipment and a Voice Recognition System robust enough to work in the noisy environment of an aircraft. Standard military intercom boxes were used to amplify and route audio signals. Standard Hewlett-Packard equipment was used to interface between the expert system and the radios. For communication equipment, two UHF AN/ARC-164, one VHF AN/ARC-186 and one WSC-3 radio for Satellite Communications (SATCOM) were used to show proof of concept. These radios were connected to outside antennas and the operator of the ECLM was able to contact base tower personnel via UHF and VHF frequencies and was able to contact a simulated command center via a satellite by tuning the radios via simple voice commands.


06A

HYDRAULIC SYSTEM PROBLEM ON UH-1H HELICOPTERS SOLVED

Payoff

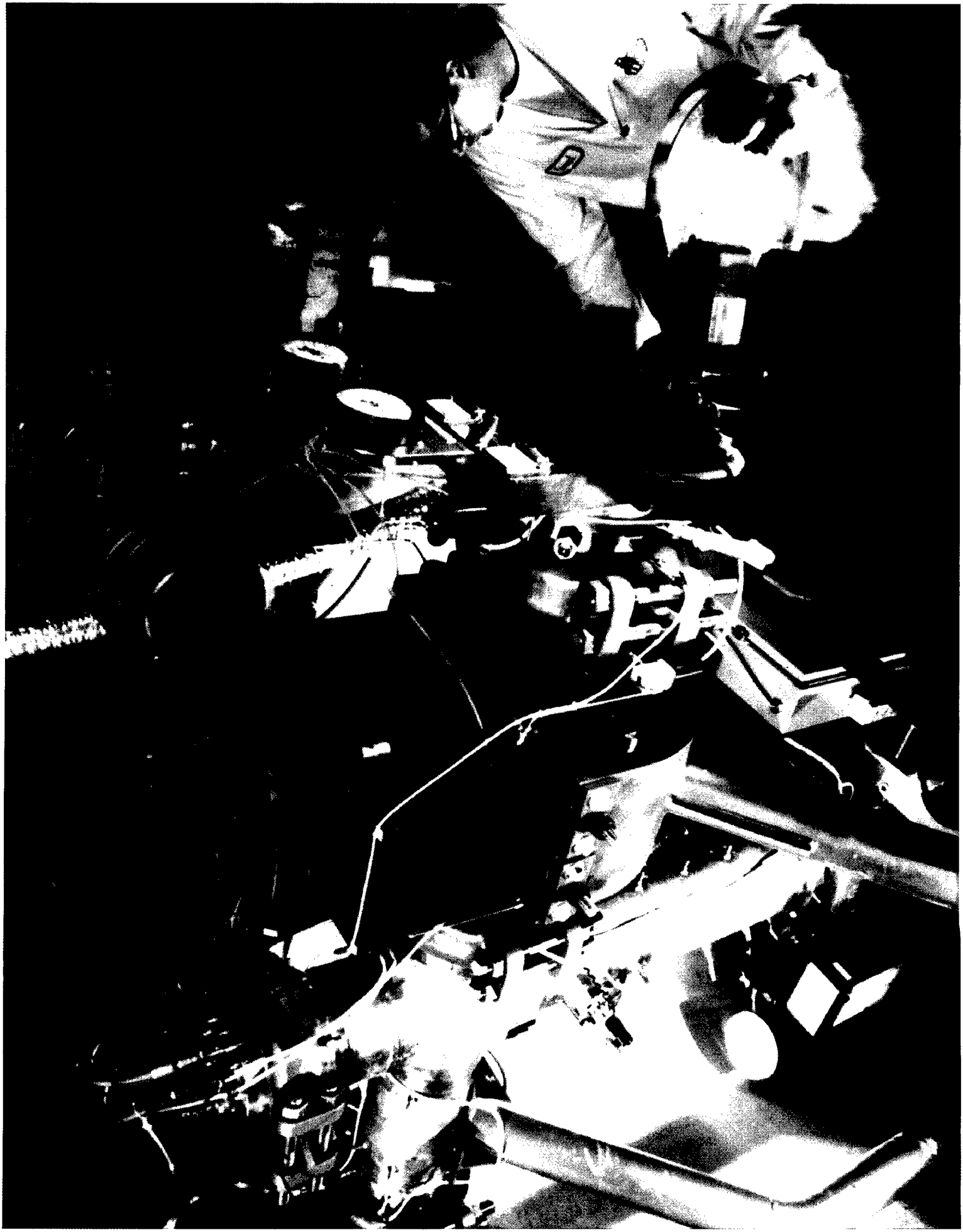
As a result of investigative research performed by the Materials Directorate Lubricant Research and Development Team, locking problems of the main rotor servoactuators in the US Army Aviation School's UH-1H helicopters were solved and the school's fleet of 150 UH-1H helicopters was returned to full operational status. An analysis procedure developed by the team enabled the school to verify the solution to the problem and allowed the Army to avoid a costly redesign or replacement of servoactuator stock valued at $32 million.

Accomplishment

A team of engineers in the Materials Directorate's Nonstructural Materials Branch helped maintenance personnel at the US Army Aviation School at Fort Rucker AL solve a recurring hydraulic system problem that had forced the grounding of most of the school's UH-1H helicopter training fleet. After tracing the source of the problem to the servoactuator (servo) poppet valve, the team recommended a repair procedure that enabled the school to return its helicopters to full operational status.

Background

Helicopter flight training for all US military services is conducted at the Army's Aviation School using UH-1H helicopters. A critical component of this aircraft is the main rotor servo. It provides hydraulic boost assist to the cyclic and collective controls via a single 1000 psi hydraulic system and can be operated manually with no hydraulic supply. One flight training maneuver the instructors employ is cutting off hydraulic boost at a certain altitude so that student pilots can practice making boost-off landings using manual controls. For safe boost-off flight, the servo must operate freely, with no lockup. If a servo lockup is observed during the pre-flight check, the helicopter is grounded until the problem is resolved. Since 1992, a large number of unscheduled helicopter groundings, due to servo lockup, has disrupted the progress of several pilot training classes and seriously impacted mission readiness. To remedy this problem, the Army, in July 1995, requested help from the Directorate's Lubricant Research and Development Team that had developed the MIL-H-83232 hydraulic fluid used in the UH-1H helicopters. The problem was traced to a sticking servo poppet valve that froze the hydraulic system and left thin concentric rings on the valve face. Fourier Transform Infrared microscopic analysis revealed that the concentric rings on the valve face were films of barium dinonylnapthalene sulfonate (BSN), a relatively unstable material under heat and pressure used as a rust inhibitor in preservative type hydraulic fluid but not in service-type hydraulic fluid. This preservative fluid was not being completely drained from the servos after they were removed from storage, causing a buildup of BSN in the service hydraulic fluid. When the power-off flight maneuver was initiated, the servo poppet valve would cycle as many as 10 times per second, causing a severe rubbing problem as a small amount of the uncirculating fluid (trace contamination) was stressed and heated. Thermal degradation products from the BSN reacted with the metal causing sticking of the valve component.



Supercritical Carbon Dioxide Process Eliminates Hazardous Materials from Aerospace Component Cleaning Operations

Payoff

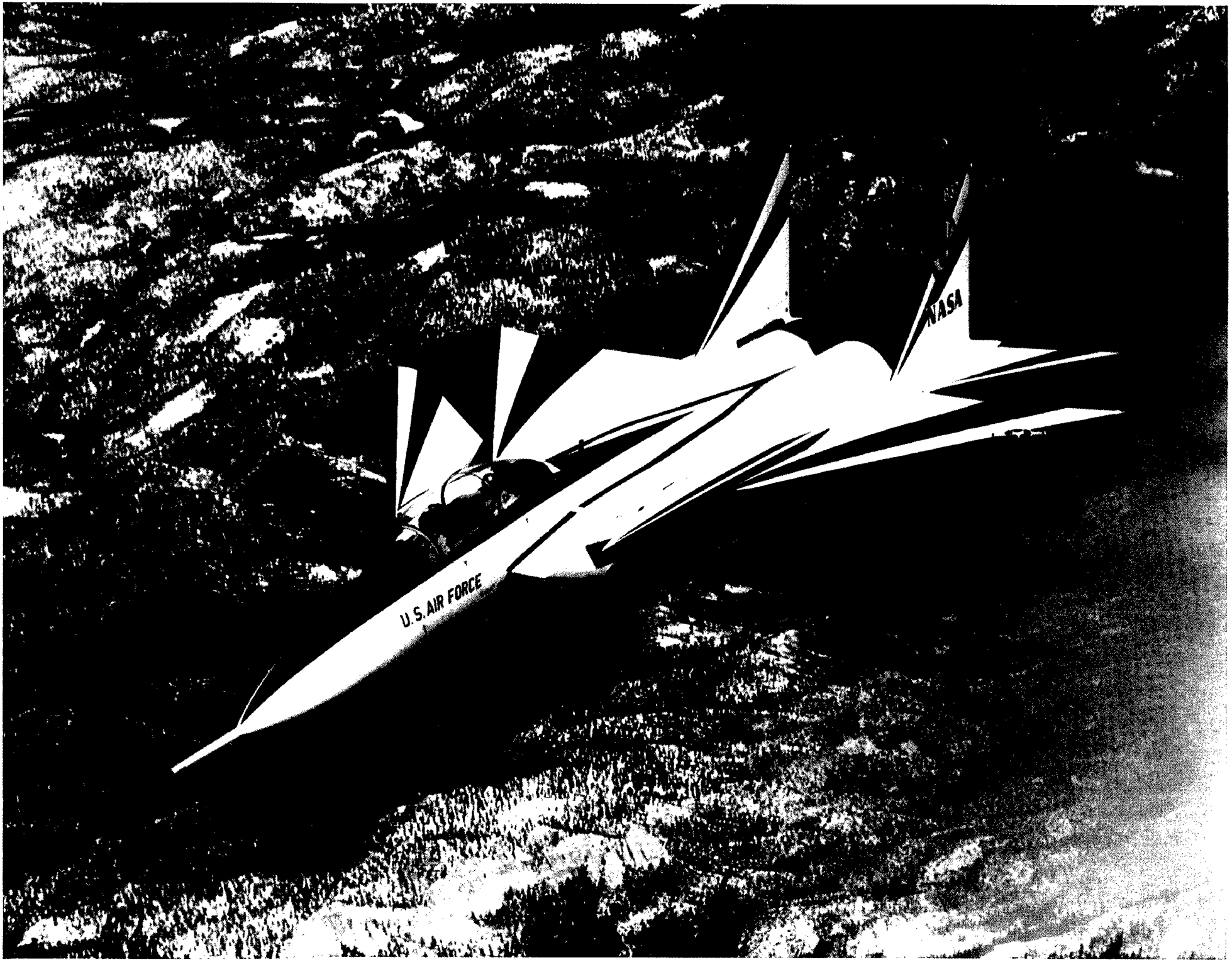
The supercritical carbon dioxide ($SCCO_2$) process for cleaning Air Force weapon systems components is designed to operate effectively with no volatile organic compounds, ozone depleting substances or gaseous emissions. The waste stream generated is held to an absolute minimum, and contains no hazardous volatiles. The $SCCO_2$ process can ultimately save the Air Force $500,000 per unit per year through reduced solvent/waste disposal and incineration costs and reduced cleaning equipment and materials costs.

Accomplishment

The Materials Directorate, working with engineers at the Southwest Research Institute of San Antonio TX, developed a process for cleaning small, precision components and assemblies during manufacturing or repair that doesn't use volatile organic compounds or ozone depleting substances. Their environmentally safe $SCCO_2$ process for cleaning weapon systems components removes oils, greases and waxes by natural convection flow in a pressure-controlled chamber.

Background

In the manufacture and maintenance of Air Force weapon systems, small, precision components often become contaminated with oil, grease or waxes that must be removed. For decades, cleaning processes using ozone-depleting vapor solvent materials, i.e. chlorofluorocarbon or trichloroethane, were used to remove these contaminants. Alternative cleaning processes, capable of delivering equal performance while using environmentally friendly solvents, are being investigated for integration into metal processing systems. One such process is the cleaning process using non-toxic, nonflammable $SCCO_2$. In this process, carbon dioxide becomes a liquid at 30°C to 80°C, operating under pressures of 900 to 2,000 psi. The liquid cascades down over the components by natural convection, causing temperature zones in the chamber to dissolve contaminants. The contaminants are released at the bottom of the chamber for easy waste-only removal while the CO_2 with no dilution rises naturally to the top of the chamber where it is cooled into a liquid and used again to repeat the cleaning process. This simple computer controlled process is effective for quick contaminant removal from parts such as precision ball bearings, electronic components, gyroscope assemblies, turbine components, valves and precision gear assemblies. Components are cleaned while rotating in a 9-inch by 12-inch basket that has a 70-pound capacity. The use of environmentally friendly cosolvents as additives to the process are being investigated to increase the rate and range of contaminants and soiling that can be removed. A patent for the $SCCO_2$ process has been issued to Southwest Research Institute. Following the development of a workable production unit, a full-scale field demonstration at an Air Force Air Logistics Center will be conducted.


NASA
U.S. AIR FORCE

F-15 WITH THRUST-VECTORING NOZZLES GOES SUPERSONIC

Payoff

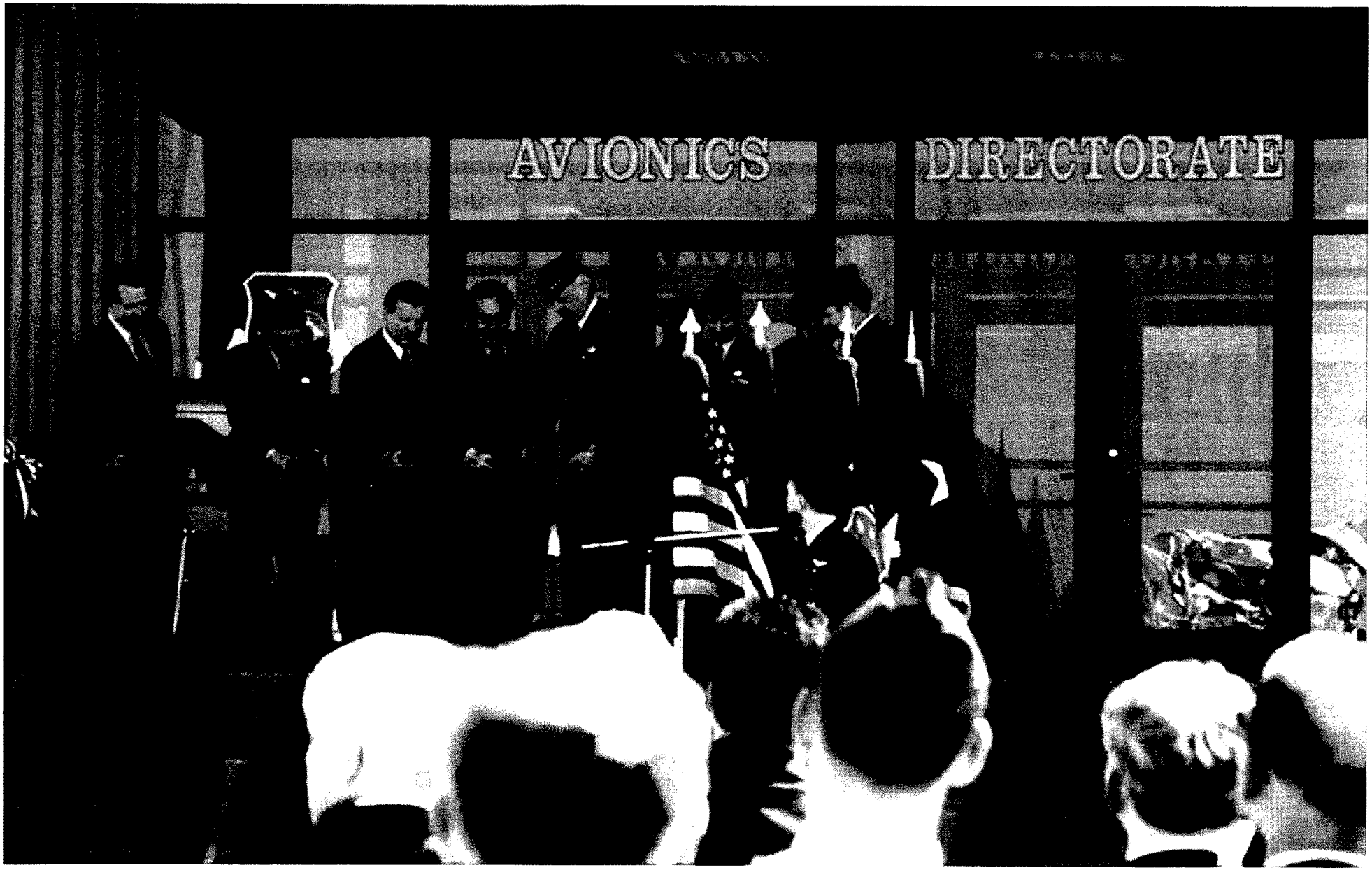
Thrust-vectoring nozzles on fighter aircraft will enable greater control authority across the flight envelope from take-off and landing to speeds up to Mach 2. This will be achieved through the total integration of the propulsion/nozzle control system in to the flight control system. Such advances in engine-nozzle technology will extend aircraft range, increase maneuverability, prevent loss of control and reduce weight and operating costs.

Accomplishment

Under a program sponsored jointly by the Flight Dynamics Directorate and the National Aeronautics and Space Administration, an Air Force F-15 fighter aircraft equipped with pitch-yaw thrust vectoring nozzles, to control the direction and power of its two engines, flew into the supersonic vectoring arena for the first time at Edwards Air Force Base CA. This research test bed is part of the cost-shared, joint venture Advanced Control Technology for Integrated Vehicles (ACTIVE) program that includes Pratt & Whitney and McDonnell Douglas Aerospace.

Background

The ACTIVE research program began in 1992 with the goal to flight test the new pitch-yaw thrust vectoring nozzle hardware design and to demonstrate the performance payoffs achieved from totally integrating the propulsion system into the aircraft flight control system. The F-15 ACTIVE test bed aircraft produces about 4,000 pounds of vectoring force from each engine that can be applied in both pitch and yaw directions. This translates into 8,000 pounds of additional aircraft maneuvering control power of plus or minus 20 degrees in any direction at the nozzle exit area, which generates large force moments about the aircraft's center of gravity. The new balance beam nozzles are basically the standard F-100-PW-229 engine nozzles with three functional changes. The goal of the ACTIVE program is to fly the F-15 aircraft at speeds up to Mach 2 without either of its vertical stabilizer tails and demonstrate handling qualities equal to or better than the current F-15E. The digitally integrated electronic controls of the propulsion system will provide increased flight control authority through the thrust-vectoring nozzles.


AVIONICS
DIRECTORATE

New 21st Century Avionics Vision Begins with Ribbon Cutting Ceremony

Payoff

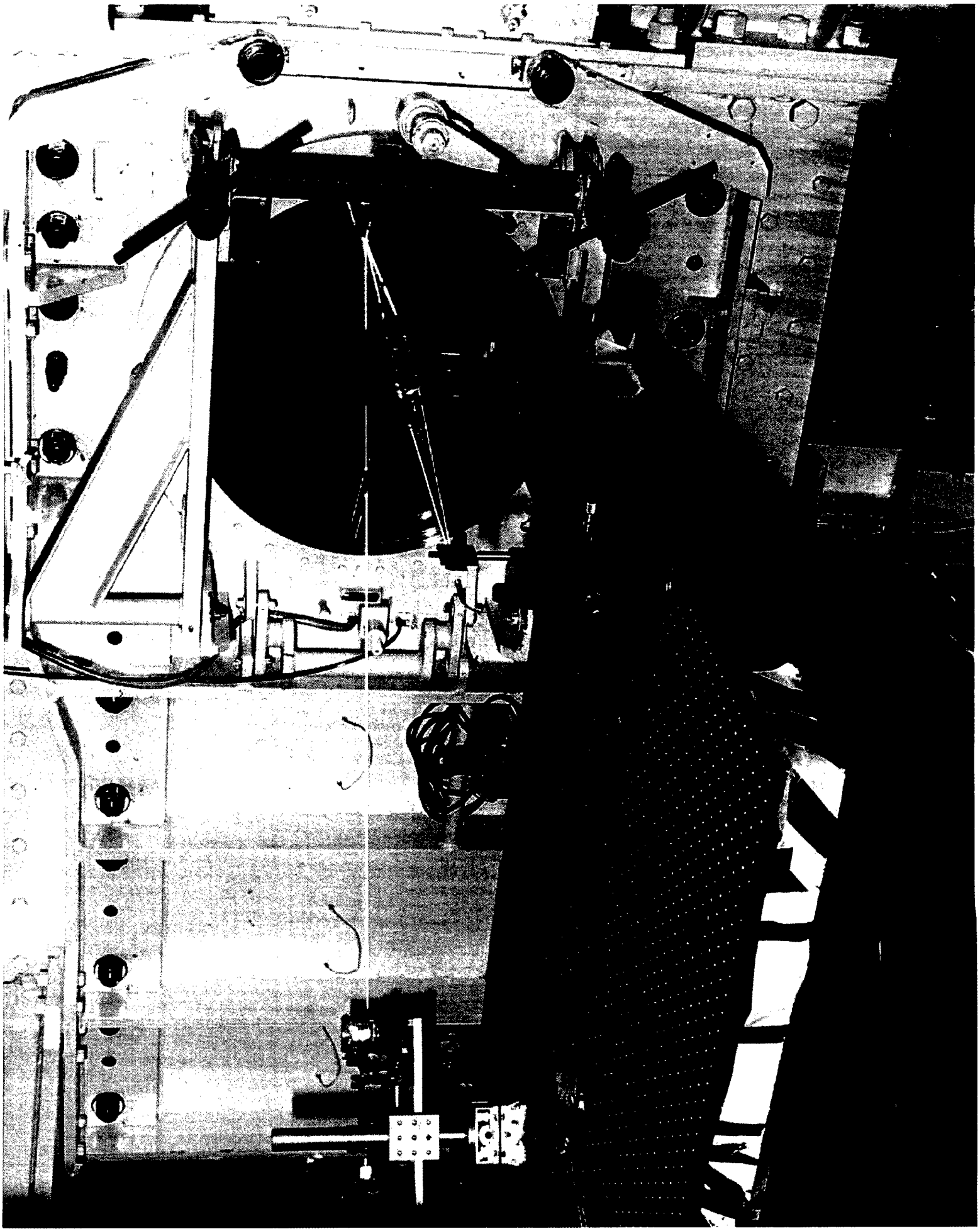
The new avionics research and development facility is an endorsement of the 21st Century Avionics Vision that recognizes the critical role information and avionics technologies play in national security and the need for avionics modernization. The integration of facilities at Wright Laboratory's Avionics Directorate is a key step toward developing tomorrow's combat edge through affordable avionics.

Accomplishment

More than 300 government and contractor personnel witnessed the cutting of a ribbon by civilian and military dignitaries that christened a new research facility and acknowledged the re-engineering of the Avionics Directorate into a comprehensive avionics and electronics research and development team. This ceremony symbolized Wright Laboratory's commitment to the 21st Century Avionics concept of creating a unified, multi-division development of open architecture, integrated avionics.

Background

During the late 1980's, the Avionics Directorate was faced with providing the same level of support to its customers with less resources. The ever changing Air Force mission requires avionics systems, that support a variety of new requirements, to be increasingly flexible, timely and precise in their application. To meet this challenge and insure continued excellence in avionics and electronics, Wright Laboratory decided to integrate the Solid State Electronics Directorate and the Avionics Directorate to form a single, streamlined organization. This integration became one of the milestones in implementing a new concept called the 21st Century Avionics Vision. This vision allows the integration of Avionics Directorate facilities to solve the majority of the Air Force avionics needs in a more affordable way. To commemorate this event, Representative Tony Hall; Representative David Hobson; Lieutenant General Richard Scofield, Aeronautical Systems Center Commander; Major General Richard Paul, Director of Science and Technology, Air Force Materiel Command; Brigadier General Todd Steward, AFMC Civil Engineering; Colonel Garald Robinson, 88th Air Base Wing commander; Colonel Richard Davis, Wright Laboratory Commander; Mr. Michael Koecheck, Vice Chairman of Monarch Construction; and Dr. Jesse Ryles, Avionics Directorate director, participated in the ribbon cutting ceremony. Representatives Hall and Hobson along with Senators Mike DeWine and John Glenn and Lieutenant General Scofield, Colonel Davis and Dr. Ryles endorsed the new 21st Century Avionics Vision by signing a proclamation.



Optically Smart Surface Technique Expands Nonintrusive Diagnostics Capability

Payoff

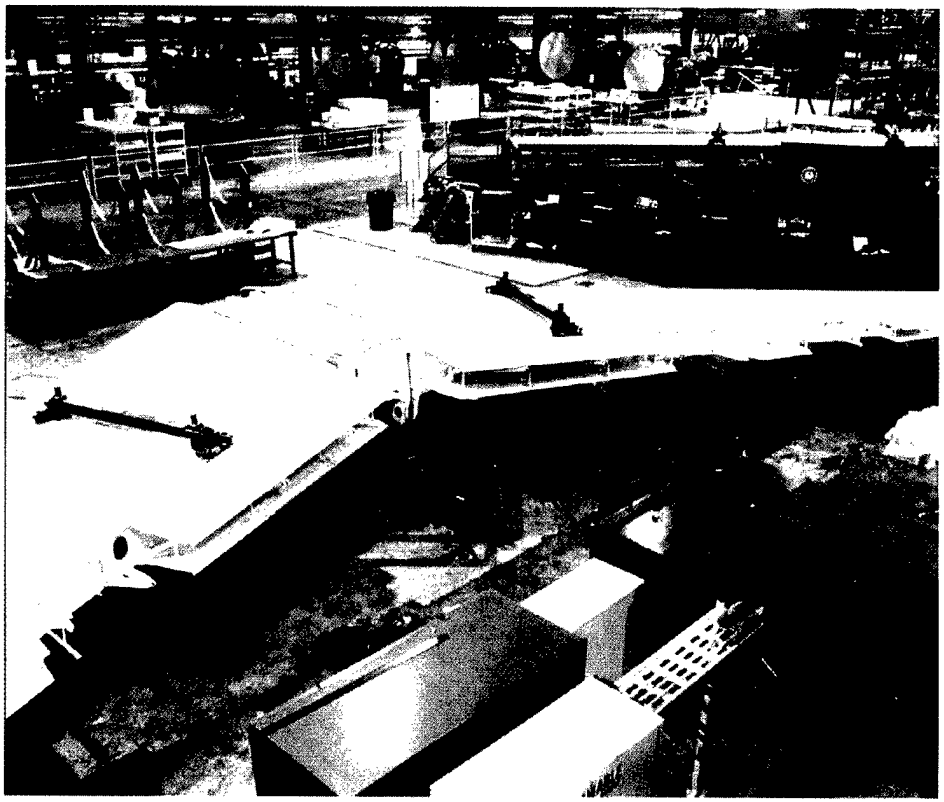
The optically smart surfaces technique can be used to overcome some of the geometric limitations of conventional laser velocimetry systems to obtain aerodynamic measurements in wind tunnels that were not previously possible. This technology will increase the understanding of aerodynamic flows associated with subsonic and supersonic vehicles.

Accomplishment

Through the combined efforts of the Flight Dynamics Directorate's Aeromechanics Division and MetroLaser, a new optical technique for measuring aerodynamic parameters has been developed, tested and validated at subsonic speeds in a full-scale transonic wind tunnel. This new technology, called "optically smart surfaces," enables the measurement of aerodynamic parameters in locations and modes that the geometry of traditional optical systems does not permit.

Background

For at least two decades, optical nonintrusive diagnostics techniques have been used for the measurement of aerodynamic parameters. The optically smart surface technology is intended to augment traditional optical techniques, not to replace them. It is essentially a surface relief hologram that is placed on an aerodynamic model or surface. Upon reconstruction of the hologram with a reference laser beam, it can detect surface or near surface physical parameters. For instance, a laser velocimeter can be made by recording the image of two laser beams (a probe volume). When played back, it forms the real image of two laser beams crossing and therefore constructs a laser velocimeter probe volume. The optically smart surface laser velocimeter sensor has several advantages over conventional laser velocimeter techniques, such as, reliance on forward scattered light intensity instead of the weaker backscattered light, (which may be several orders of magnitude smaller), requiring optical access from only the side of the model where measurements are to be acquired, being able to place the probe volume extremely close to the surface and finally, since the probe volume height is independent of model position, the motion of the model due to vibration or drift does not affect the position of the sample volume relative to the model's surface. The optically smart surface laser velocimeter sensors were used in the tests conducted in Wright Laboratory's Transonic Gasdynamics Facility to measure the freestream and boundry layer velocity profiles in a range of Mach numbers from 0.30 to 0.85. Similar optically smart surfaces systems can be used to measure skin friction, strain and boundry-layer transition.



WRIGHT LABORATORY TEAM MEMBERS RECEIVE MODEL OF EXCELLENCE AWARD

Payoff

Working in conjunction with personnel from Defense Contract Management Command, Northrop Grumman Vought-Commercial Aircraft Division, McDonnell Douglas Aerospace and the C-17 Systems Program Office, the Wright Laboratory team members demonstrated that government and industry working together can define business practices that provide gains in affordability. Using the C-17 horizontal stabilizer to demonstrate the Military Products Using Best Commercial/Military Practices pilot program's initiative for change and employing design for manufacturing techniques, process and product improvements were made that resulted in a 53 percent projected reduction in acquisition cost.

Accomplishment

The Military Products Using Best Commercial/Military Practices Team was presented McDonnell Douglas Aerospace's Annual Model of Excellence Award on 26 April 1996 for demonstrating integrated product definition, providing extraordinary service to the customer and using creativity and discipline to demonstrate processes that reduce cycle times and yield significant savings to the product. The Model of Excellence Award, McDonnell Douglas Aerospace's highest form of recognition, is designed to acknowledge individuals and teams who have made the ultimate contribution in quality to the organization through superior innovation.

Background

Under a pilot program sponsored by the Manufacturing Technology Directorate, McDonnell Douglas Aerospace implemented a phased program to stimulate the industrial base, motivate positive change throughout the DoD and the commercial sector and encourage "dual use" commercial processes, practices and factories. Phase I of the Military Products Using Best Commercial/Military Practices pilot program was initiated with the primary structural outer torque box for the C-17 horizontal stabilizer selected as the component to demonstrate the program's initiatives for change. This phase allowed for the development of a process improvement methodology that enabled the analysis and validation of business practice and manufacturing infrastructure improvements. The improvement process began by baselining the current commercial and military approach to a given process. Key measurements that were collected included head count and cycle time. Specific improvement initiatives were developed and a cost benefit analysis was performed by the pilot team and the functional owners of the process. The pilot investigated a total of 44 practice/process initiatives, reducing practice/process costs by a projected 36 percent when compared to the Phase I baseline. An award fee process was developed which focused on team building and continuous improvement rather than the traditional adversarial process. The contract was awarded with only a three-page statement of work written with performance terms and only five contract deliverable data items. Six integrated product teams (IPTs) are being used to manage and perform the work on the pilot. Government members have provided value-added participation on each IPT. This effort also resulted in an improved quality system demonstration on the C-17 production line at Northrop Grumman Vought-Commercial Aircraft Division.

XHBT94
ECL 94C3
VCC
GND
VBE1
VBE2

New Heterojunction Bipolar Transistor (HBT) Fabrication Technology Transferred to Industry

Payoff

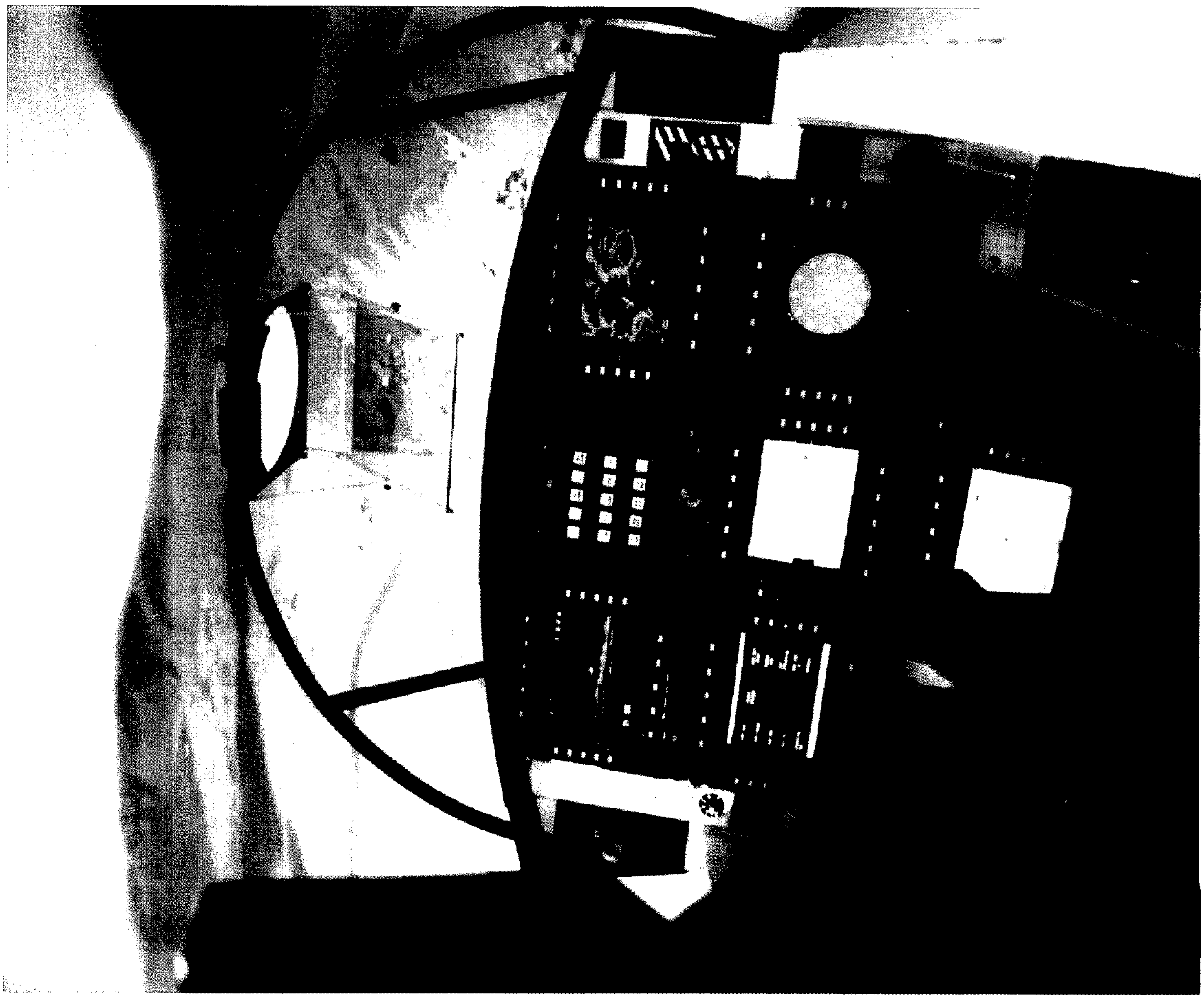
The transfer of improved HBT fabrication technology to leading industrial research and development laboratories creates a technology base that will enhance the performance of military and commercial solid-state microwave radar and communications systems and lower system cost. It represents a breakthrough which will impact the performance, efficiency and cost of all classes of systems that use solid-state microwave power generation.

Accomplishment

Engineers in the Avionics Directorate's Electron Devices Division developed an advanced fabrication process for thermally shunted heterojunction bipolar transistors (TSHBT) and transferred it to Lockheed Martin, Northrop Grumman, Hughes, Raytheon, Texas Instruments and other companies. The Directorate entered into a Cooperative Agreement with Northrop Grumman and Epitronics to fabricate dual-use microwave monolithic integrated circuits using TSHBT technology.

Background

Advances in solid-state electronics technology have led to the emergence of HBTs as a viable contender for applications that require high-power, high-efficiency and high-linearity signal amplification. While HBT technology has existed for more than a decade, power densities demonstrated with HBTs have fallen far short of expected values due to a thermal runway problem. As the device operates, it heats up; and then it either catastrophically fails or shuts itself off. Various HBT designs were not able to overcome this instability problem until the Avionics Directorate developed their innovative thermal shunt approach. The Directorate has designed and fabricated microwave power devices with state-of-the-art performance; however, like the fabrication of all other HBT devices, the process used was complex, expensive and poorly understood. DoD was not likely to take advantage of TSHBT technology unless there was a significant improvement in the fabrication process for TSHBT devices. The transfer to Lockheed Martin involved a collaborative effort, whereby the TSHBT technology was inserted into two of Lockheed Martin's microwave monolithic integrated circuits with excellent results.



Wright Laboratory Team Receives Award for Avionics Simulation and Evaluation Technologies

Payoff

The Distribution Interactive Simulation (DIS) Team's demonstration showed that DIS technologies can be useful for performing experiments and making design decisions on weapon systems. DIS enables a site with the proper protocol data units to develop avionics systems within their own speciality and interact with specialists in other areas.

Accomplishment

A Wright Laboratory led DIS Team received an Air Force Materiel Command Technology Achievement Award for major contributions to the state of the art in avionics simulation and evaluation technologies. The joint DIS Team demonstrated the ability to evaluate actual avionics hardware and software in a long-haul DIS exercise.

Background

The DIS node is integrated with the interlab simulation complex in the Avionics Directorate to provide a gateway to other national simulation and testing resources. The proof-of-concept demonstration of the DIS networking technologies during the 17th Interservice/Industry Training Systems and Education Conference, held on 13-17 November 1995, consisted of 26 cooperating simulation nodes drawn from industry, government, national labs and universities. The team participated in five real-time air, land and sea combat demonstrations daily. The avionics hardware used was a subset of the F-22 modular architecture. An Ada operating system and Ada application software were included in the demonstrations. The DIS demonstrations were a joint effort between Wright Laboratory's Avionics and Flight Dynamics Directorates, the Army, TRW, FAAC and Amherst Corporations. The simulation was conducted under the Avionics Directorate's Integrated Test Bed in-house project that supports the research, development, test and evaluation of advanced avionics architectures and subsystems within a real-time and realistic simulation environment.

New Aerospace Nondestructive Inspection System Benefits Indy-Type Race Teams

Payoff

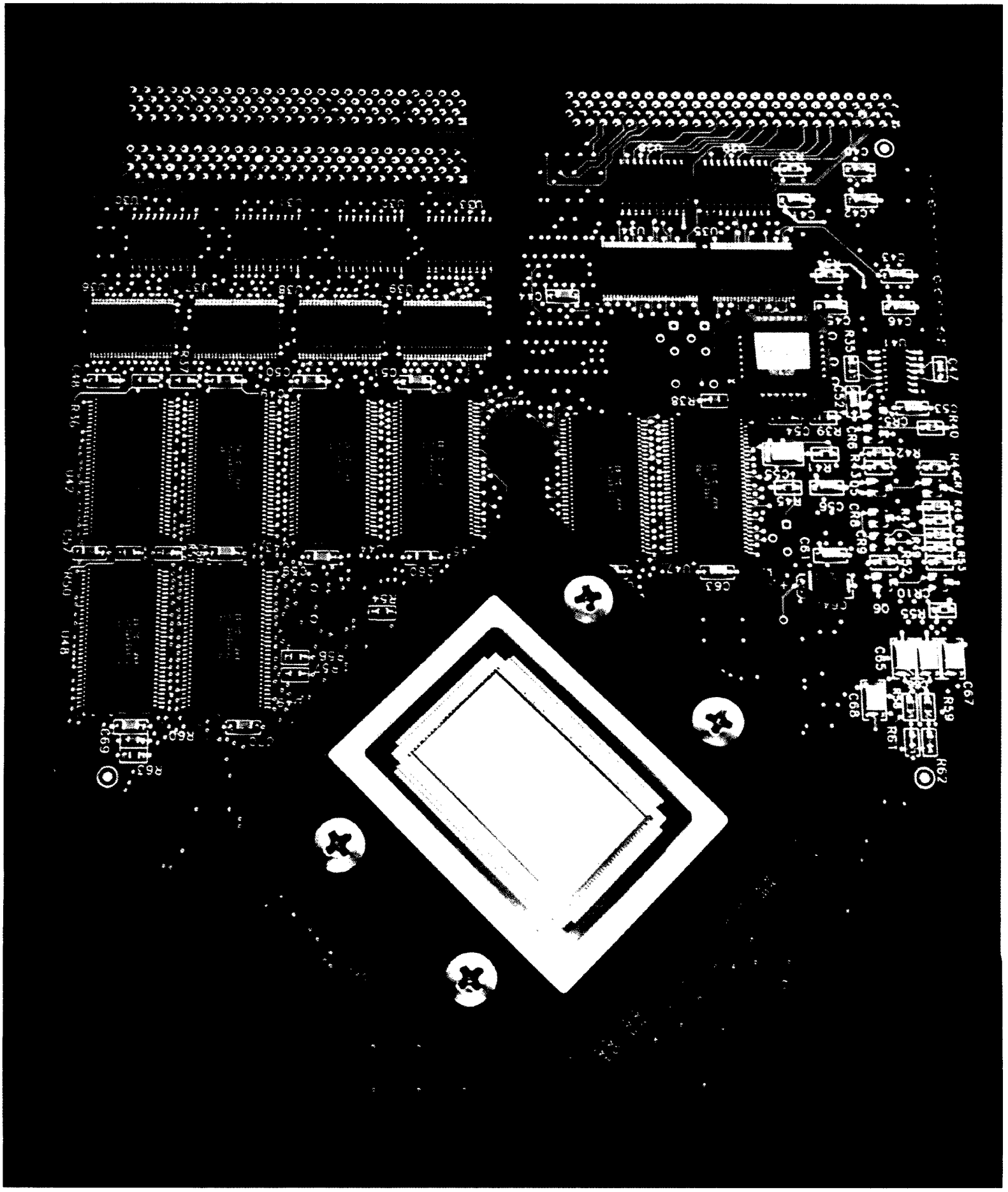
The Mobile Automated Scanner (MAUS), designed for nondestructive inspection of weapon systems, offers a new capability to the racing industry to conduct effective nondestructive testing of cars, such as Indy-type racers, to increase driver safety. Air Force experience gained from this dual use application, will aid in the development of smaller scanners for use in tighter areas.

Accomplishment

Engineers at Wright Laboratory's Materials Directorate and McDonnell Douglas Aerospace demonstrated to the United States Auto Club a highly accurate nondestructive testing device that can be used to reveal hidden flaws and damage to composite bodies of Indy-type racing cars. Their MAUS, originally developed for portable nondestructive inspection of Air Force weapon systems, enables accurate and thorough non-destructive inspection of race car structures to assess body material integrity and hidden damage.

Background

When racing car bodies were all metal and bolted onto a frame, they could be repaired by welding, riveting or simply pounding out the dent. Today's racing cars combine the frame and body much like an aircraft fuselage and are made largely of composite materials. In a crash, the body does not incur dents but may crack, and the full extent of damage may not be visible. When hidden damage is identified through a rudimentary tap test, the bad spot is cut out; a composite repair is bonded in place; and the car is put back out on the track. As crashes and repairs mount up, the integrity of the vehicle deteriorates. It becomes torsionally unstable while going through turns and is eventually unfit for competition. As racing speeds increase, sanctioning bodies, such as the United States Auto Club (USAC), want to improve driver safety by identifying subsurface frame and body flaws and hidden damage in the earliest stages possible. The MAUS, developed by McDonnell Douglas Aerospace of St. Louis MO, uses pulse echo and resonance ultrasonics to identify flaws and damage in large composite aircraft structures, as well as, composite airframe components. The potential of using this unit to define the internal status of Indy car bodies was demonstrated to USAC at several racing events during 1995 and 1996. In one inspection, a surface 12-inch crack actually turned out to be a 24-inch subsurface delamination. Using a scanning head slightly larger than a computer mouse, the MAUS unit has also been used to assess adhesive bonds between composite-composite and composite-metal race car components, identify laminar flaws and assess crash damage. With its contour-following compact design, the MAUS unit can interrogate a wide variety of structural composite areas of a race car. Besides racing cars, MAUS technology is being considered for use with racing boats, wind turbine blades and in the oil, gas and nuclear industries.



High Definition Display Technology Gives Pilot Clear View

Payoff

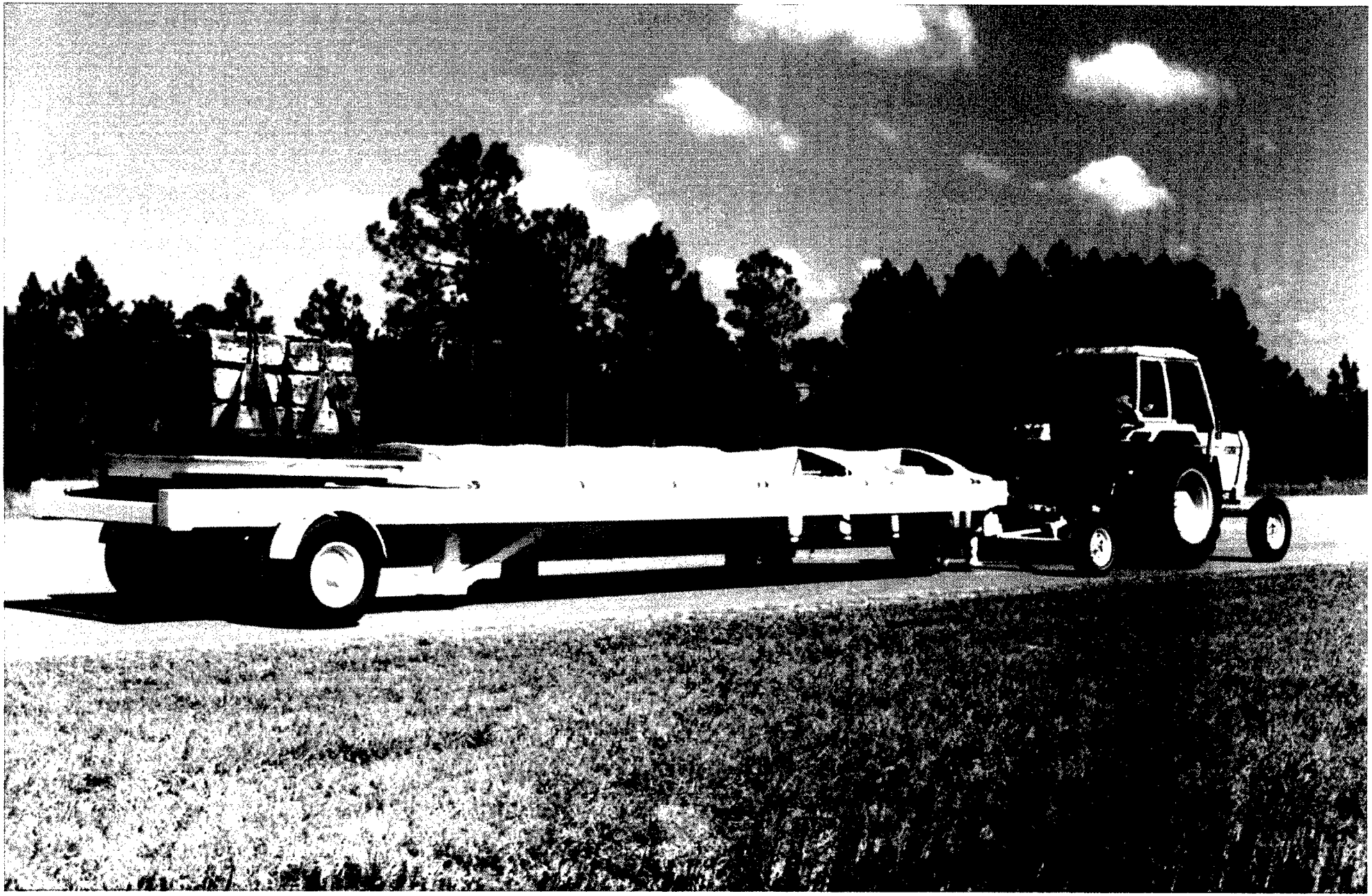
By using a high-resolution digital micromirror device, cockpit display projectors will provide a display contrast of greater than 200 to 1, an improved picture with frame rates of more than 180 per second and a factor of 10 increase in reliability. This technology provides a low -cost capability to evaluate and select the most affordable, technical solution for current aircraft displays and future displays for the Joint Advanced Strike Technology Program.

Accomplishment

Under a program sponsored by the Avionics Directorate's Cockpit Avionics Office, Texas Instruments of Dallas TX developed a lightweight, high-definition display protector that eliminates the problems associated with current cathode ray tube cockpit displays. Based on a digital microwave device, the projector has a resolution of 2048 by 1152 pixels with 1920 by 1080 active pixels and uses an all digital interface that offers virtually an unlimited connectivity capability.

Background

Current electronic cockpit displays suffer from inherent problems of low reliability, high-power consumption, excessive weight and depth and poor sunlight readability. The prototype high-definition display developed by Texas Instruments eliminates these problems. It is an electromechanical semiconductor component with small, highly reflective mirrors (16 microns square) built over a standard static random access memory structure. Each device covers a memory cell with a movable micromirror. Electrostatic forces, based on the data in the memory cell, tilt the mirror either a positive 10 degrees (on) or a negative 10 degrees (off), modulating the light incident on its surface. Light reflected from "on-mirrors" passes through the projection lens and creates images on a large screen. Light from "off-mirrors" is reflected away and trapped. The proportion of time during each video frame that a mirror remains in the "on-site" determines gray scale. Colors may be added by either a color wheel or by using three digital micromirror devices. This device makes these projectors high-contrast displays, with a resolution exceeding the European standard projector by more than a factor of 2. The commercialization of this technology by Texas Instruments will allow the Air Force to further export this unique technology for military applications at significantly reduced cost.



Rolling Weight Deflectometer (RWD) Provides Complete Evaluations of Airfield Pavements

Payoff

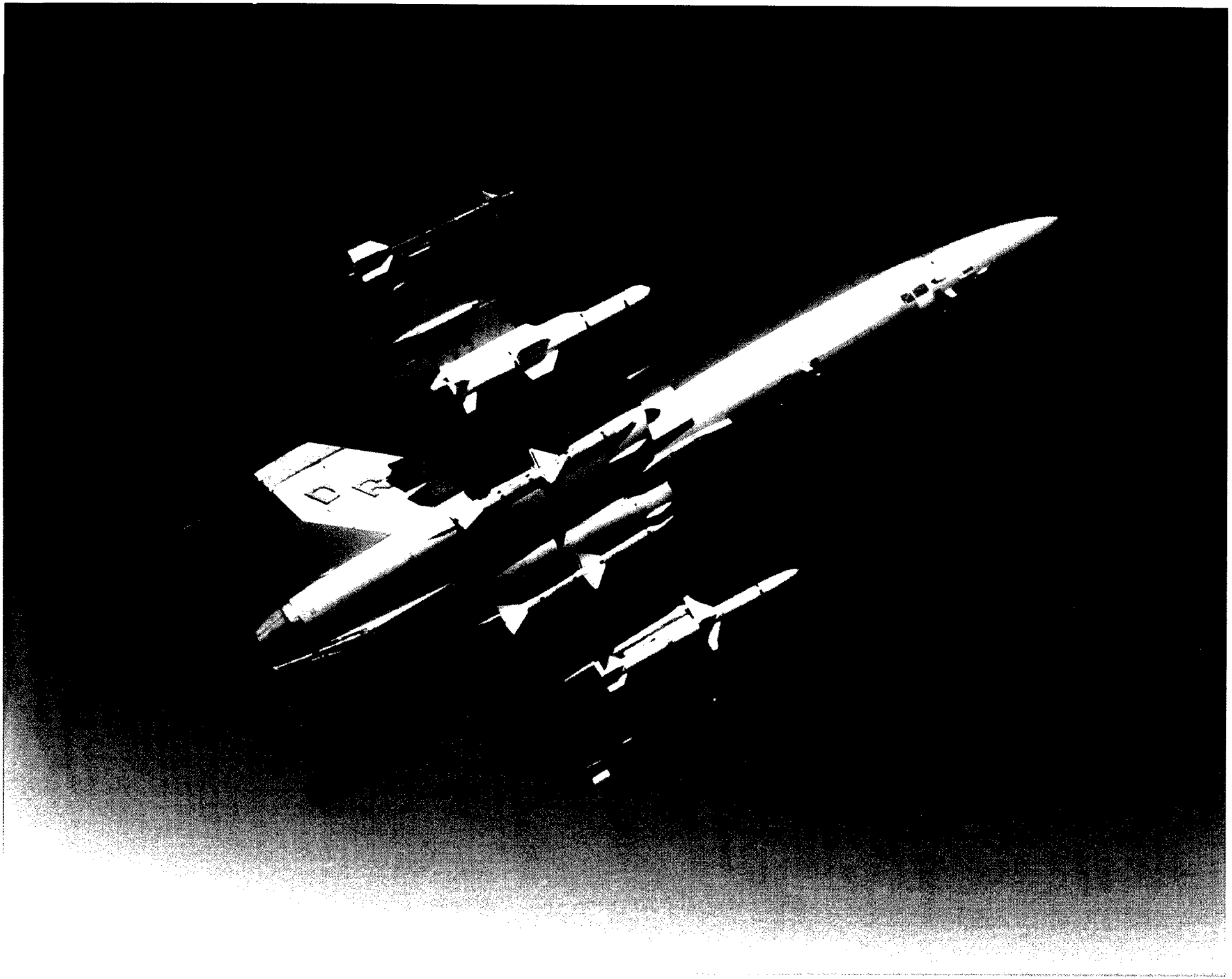
The RWD, a continuous pavement load-response measurement system, will enable Air Force pavement evaluation teams to obtain a more complete and accurate assessment of the ability of airfield pavements to carry aircraft traffic associated with specific mission requirements. A scaled down commercial version of the system could be used to evaluate the integrity of highways.

Accomplishment

Under a program sponsored by the Flight Dynamics Directorate's Air Base Technology Branch at Tyndall AFB FL, Quest Integrated, Inc. of Kent WA developed a pavement load-response measurement system called the RWD that continuously evaluates the structural response of a pavement to a moving load. Actual pavement deflections are measured with this non-destructive pavement evaluation tool immediately adjacent to a loaded F-15 tire as the RWD moves along at speeds up to 4 miles per hour.

Background

The ability of airfield pavements to carry aircraft traffic associated with specific mission requirements has historically been assessed by pavement evaluation teams using a suite of destructive, quasi-destructive and nondestructive evaluation tools. The process is time consuming and current procedures only provide load capacity assessments or adjusted gross load numbers at discrete points on the airfield. Even a very thorough pavement evaluation provides structural integrity information for less than 2% of the total operating surface. Nondestructive evaluation is based on visual inspection and the output from a seismic analysis device known as the heavyweight deflector (HWD). The HWD provides information on pavement strength and response to a given load at discrete locations on the airfield. The information is considered reliable, but data is only collected at intervals of 50-200 feet unless problems are identified in a given area. The RWD gets around this problem by providing the capability to continuously measure the load-response characteristics of a pavement along the path traveled by the device. Measurement accuracy has been confirmed by an independent measurement technique during tests performed at Tyndall AFB. Comparisons made between the RWD and a lighter version of the HWD known as the falling weight deflectometer (FWD) verified that the pavement response recorded by the RWD was consistent with that recorded by the FWD. Furthermore, the RWD found weak and strong areas of the pavement that were not detected by the FWD.



Application of Mission Environmental Requirements Integration Technology (MERIT) System Results in Cost Savings

Payoff

Using the MERIT system to provide realistic environmental criteria in a timely manner enabled the Navy to determine a credible probability of failure leading them to cancel a large recall of SLAM and Harpoon anti-ship missiles to replace the fin actuators common to both systems. This cancellation avoided retrofits costing as much as $6,000 per actuator, resulting in an overall cost savings of over $8 million.

Accomplishment

Responding to a request from the SLAM and Harpoon Program Office at McDonnell Douglas, a team composed of members from the Flight Dynamics Directorate, McDonnell Douglas and the Naval Air Warfare Center performed an analysis of the operational environments for the SLAM and Harpoon antiship missiles that enabled the Navy to avoid a large recall. The request to retrofit all fielded missiles was prompted when small cracks were observed in a limited number of the fin actuators common to both systems. The MERIT team's analysis traced the growth of these cracks to excursions of temperature to minus 10 degrees and minus 25 degrees F. MERIT provided the expected life cycle occurrence of these temperatures, based on the missiles' deployment concepts, and revealed the probability of actuator failure over the 20 year life of the systems to be 2-3 in a million.

Background

The MERIT program fosters early and active team building between the customer, developer and program manager by providing realistic usage-based environmental criteria in a timely manner. MERIT achieves this by linking experience-based knowledge of the life cycle profile development process with quantitative predictions of the environmental conditions which will occur during all life cycle phases. Embedded rule-based technologies use captured expert-knowledge to guide the developer through the life cycle creation process while providing feedback to assist the user in determining the operational and design implications of each choice. In addition to reducing the time and manpower required to accomplish this task during conceptual design (from 0.5 to 1 man-years to less than 1 man-month) and limiting downstream design changes and cost by improving the accuracy and traceability of initial requirements, MERIT enables the program manager to perform effective, usage-based trade studies in near real time during the early system life to guide allocation of scarce resources.

JET SCREECH AMPLITUDE PREDICTED FOR THE FIRST TIME

Payoff

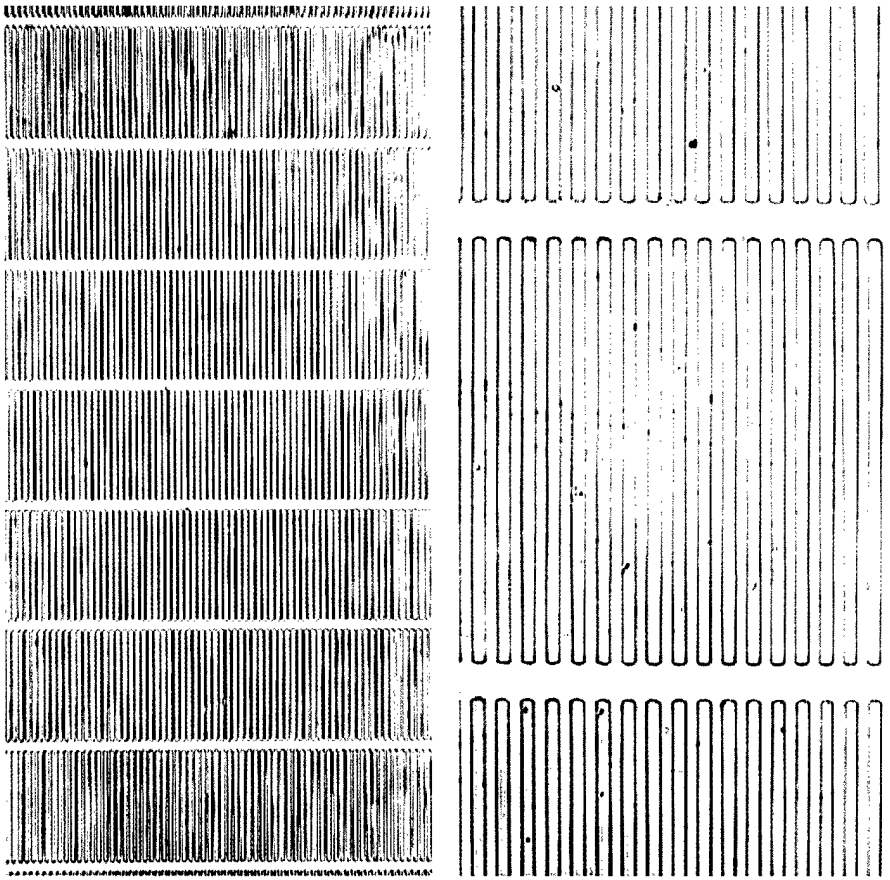
Future aircraft nozzle/aftbody configurations will rely heavily upon three-dimensional shaping and exotic materials for weight and survivability improvements. Using an analytical tool called Fluid Mechanics of Screech, early in the design phase of an aircraft system to accurately predict screech tones in the nozzle/aftbody region, will minimize sonic fatigue of nozzle external panels due to severe acoustics effects while reducing system life cycle costs.

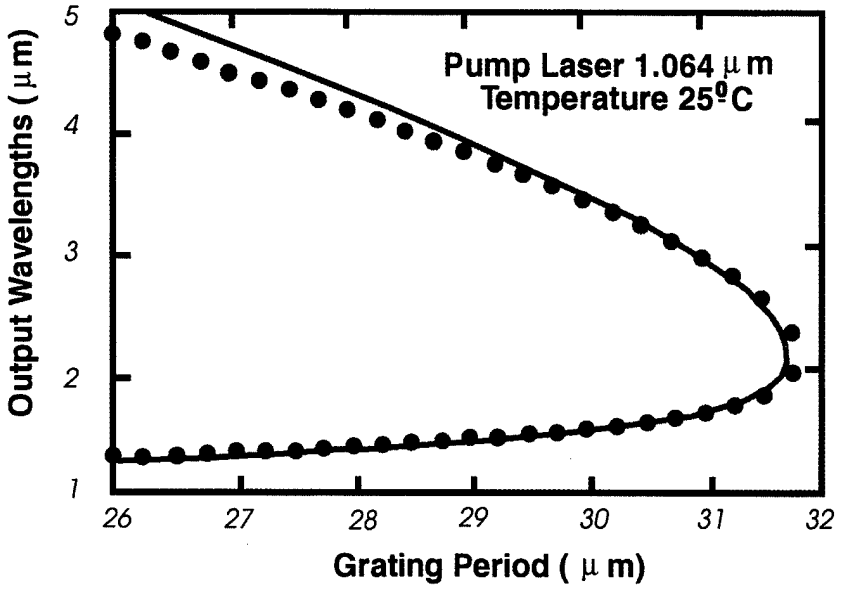
Accomplishment

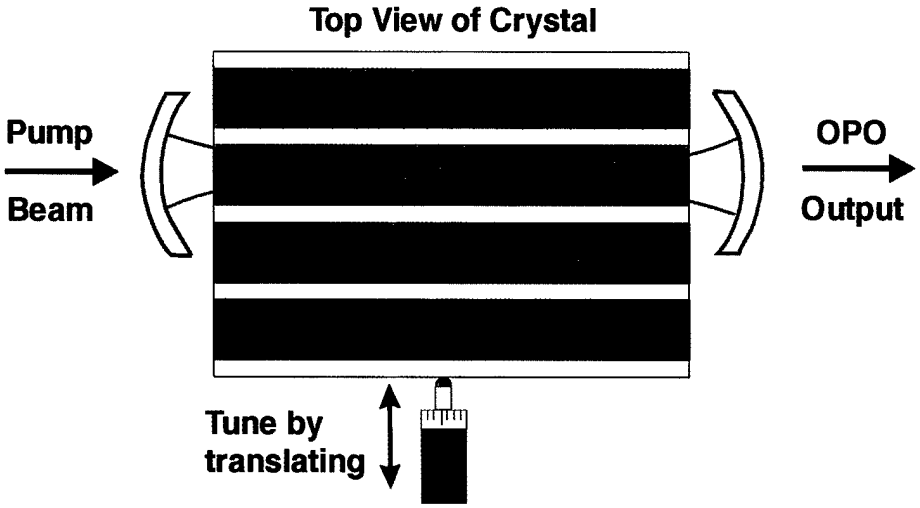
A team led by the Flight Dynamics Directorate's Aeromechanics Division developed an analytical tool called Fluid Mechanics of Screech (FLUMES) that successfully predicted both the screech frequency and amplitude of a convergent-divergent nozzle operating at a supersonic condition. A predicted screech fundamental frequency of 6953 hertz (Hz) with an accompanying amplitude of 143 decibels (dB) nearly duplicated the experimental screech frequency and amplitude of 7031 Hz and 145 dB, respectively.

Background

Acoustic levels as high as 160 dB have been measured in the nozzle/aftbody region of some closely-spaced, twin-jet aircraft such as the F-15 and B-1B. The narrowband shock noise component or screech tone identified with these high noise levels has caused sonic fatigue of the nozzle external panels for these aircraft. Since the cost of maintaining and replacing these panels is high, they have been removed. This approach may not be acceptable for future advanced fighter aircraft because of performance and survivability considerations. The FLUMES research initiative is an international, government, industry and university cooperative effort, which has used experimental, analytical and computational approaches to develop a screech analysis tool for arbitrary nozzle/aftbody configurations. Other organizations involved in the FLUMES development effort are NASA, McDonnell Douglas Aerospace, Notre Dame University and the United Kingdom Defense Research Agency. The resulting analytical tool accepts various nozzle geometric parameters such as nozzle exit height and nozzle operating conditions (such as primary and freestream pressures and temperature). For a specified range of frequencies, the sound pressure level at the nozzle lip (as a function of frequency) is calculated and plotted. This calculation can take anywhere from 5-10 seconds on a Unix workstation, depending on the strength of the screech feedback loop. The entire code is run within a graphical user interface providing point and click menus and automatic plotting and printing capabilities.




Pump Laser 1.064 μm
Temperature 25ºC
Output Wavelengths (μm)
5
4
3
2
1
26
27
28
29
30
31
32
Grating Period (μ m)


Top View of Crystal
Pump
Beam
OPO
Output
Tune by
translating

New Nonlinear Optical Material Promises Revolutionary Laser Source Development

Payoff

The development of a new nonlinear optical material has resulted in innovative devices for tuning existing solid-state lasers to a specific wavelength, extending the potential of solid-state lasers to infrared countermeasure systems and laser radar. Since the processing techniques employed in this development of periodically poled lithium niobate crystals did not include the growth of new crystals, millions of dollars were saved in the development effort. Besides its military applications, the optical material can be used for commercial applications such as remote sensing, environmental monitoring and process control.

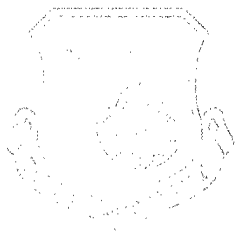
Accomplishment

Dr. Lawrence Myers of the Avionics Directorate developed a new nonlinear optical material which can be engineered for a variety of solid state laser applications. Working with an inexpensive and readily available material, lithium niobate, he used a novel material processing technique to fabricate periodically polled lithium niobate (PPLN). This led to the demonstration of the first bulk quasi-phasematched optical-parametric oscillator.

Background

Today, the main countermeasure against heat seeking missiles involves shooting flares from the aircraft to provide decoy heat sources. As offensive missiles become more sophisticated, flares become less effective. A promising development has been in the use of lasers to jam or disable the missile's sensor system. Unfortunately, few lasers possess the energy, tunability or reliability required to perform this task under combat conditions. Dr. Myers' development promises to provide the breakthrough needed to make a highly energetic, tunable, reliable, efficient, compact and all-solid state laser for an infrared countermeasure system. Using processing techniques borrowed from the microelectronics industry, Dr. Myers built into the lithium niobate crystal, a grating of domain-reversed regions which enables implementation of quasi-phasematched frequency conversion of laser light. Using quasi-phasematching, any interaction within the transparency range of the crystal can be noncritically phasematched at a specific temperature.

Additionally, the interacting waves of laser light can be chosen to select the largest nonlinear frequency conversion gain. In lithium niobate, this means a gain enhancement of about 20 times that possible using conventional phasematching. The grating period of the domain-reversed regions is controlled by the design of a lithographic mask which in turn is determined by the desired wavelength and temperature. The flexibility of the lithographic technique allows the creation of multiple grating sections on a single device. These multiple gratings allow tuning of an optical parametric oscillator by simply translating the crystal through the resonator cavity - without the need for cavity realignment. Dr. Myers' work makes possible the first practical continuous-wave and high repetition rate singly resonant optical parametric oscillator, enabling the high power solid-state laser sources needed for infrared countermeasure and laser radar systems.



Discontinuously Reinforced Aluminum (DRA) Improves Turbofan Engine Components

Payoff

The 33 percent reduction in acquisition cost, higher impact resistance and reduced life cycle cost of DRA metal matrix composite makes it the material of choice for the fan exit guide vanes on the high-bypass turbofan engines that power Boeing's 777 and the Air Force's C-17. DRA offers better extended performance, more reliability and greater operating efficiency.

Accomplishment

A program jointly sponsored by the Materials Directorate and the Manufacturing Technology Directorate's Title III Program Office, demonstrated the utility of discontinuously reinforced aluminum (DRA) as a more durable, lower cost alternative to traditional polymer matrix composites (PMCs) used in fan exit guide vanes on the Pratt & Whitney 4000 series engines. The DRA material, supplied by DWA Composite Specialties of Chatsworth CA, consists of a powder-based 6092 aluminum alloy reinforced with 17.5 percent by volume silicon carbide particles.

Background

DRA is an aluminum alloy reinforced with strong, stiff particles or fibers such as silicon carbide or alumina. In stiffness and weight-critical applications, DRA competes favorably with polymer matrix composites, titanium and aluminum alloys. Fan exit guide vanes made of PMCs have been used in Pratt & Whitney commercial turbofan engines for over a decade. While PMC vanes offer significant weight advantages over aluminum and titanium vanes, their utilization results in high acquisition costs, significant erosion by abrasive elements in flight such as rain, dirt and small hail and extremely poor impact response to hazards such as large hail. Repairs to PMC vanes are time-consuming and expensive. Through the User-Evaluator element of the Defense Production Act Title III Program, fan exit guide vanes were selected to demonstrate cost and performance advantages of DRA and to develop processing parameters for the complex double-hollow extrusion used for fan exit guide vanes. The silicon carbide in DRA provides excellent erosion resistance properties, while the ductile metallic nature of DRA provides significantly improved impact response over PMC vanes. DRA vanes are also repairable using standard metalworking techniques and procedures.

MANUFACTURING TECHNOLOGY DIRECTORATE ENGINEER RECEIVES SOCIETY OF WOMEN ENGINEERS AWARD

Payoff

As one of only three women engineers selected nationwide for the Society of Women Engineers 1996 Distinguished New Engineer Award, Ms. Mary E. Kinsella is a role model in showcasing Wright Laboratory's achievements in Air Force Manufacturing Technology.

Accomplishment

Mary E. Kinsella of the Manufacturing Technology Directorate was recipient of the Society of Women Engineers (SWE) 1996 Distinguished New Engineer Award for her leadership and contributions to the SWE and contributions to the development of military electronics manufacturing technology during the past eight years. The Distinguished New Engineer Award was established by the SWE in 1978 to honor women engineers who have been actively engaged in the engineering profession and the local community and who have demonstrated outstanding performance in engineering and leadership.

Background

Recognized at the local and regional SWE levels for her active participation in meetings and conferences, Ms. Kinsella encourages others to join in her commitment to the recognition and advancement of women in engineering. She has been very active in the South Ohio Section since she joined SWE in 1988, serving as president from July 1992 through June 1995. Her leadership as section president resulted in a 30 percent increase in membership, a more active section and more participation from the Wright-Patterson community. Ms. Kinsella chairs the SWE National Women in Government Committee (WIG). In this capacity, she organized a panel of prominent government women engineers for the 1995 SWE national convention in Boston, to discuss reengineering in the federal government. Ms. Kinsella currently manages a $21.5 million ManTech Industrial Base Pilot (IBP) program to demonstrate the production of military electronics modules on a commercial automotive manufacturing line. The IBP program, contracted to TRW Avionics Systems Division, demonstrates and implements key concepts in acquisition reform and system cost reduction using commercial practices and integrated product teams. This program will provide 30-50 percent cost savings for electronics modules compatible with the F-22 and the Army Comanche helicopter. Previously, Ms. Kinsella co-managed an $86 million joint Wright Laboratory-Advanced Research Projects Agency program in microelectronics manufacturing. Under this program, automated flexible manufacturing techniques were developed that will lower the cost of semiconductors used by the military. By using these techniques, semiconductor manufacturers can lower factory costs, reduce cycle times for small lots, increase yields and provide flexibility for many concurrent designs.

VISTA
048

In-Flight Simulation Evaluates F-22 Flight Control System Design

Payoff

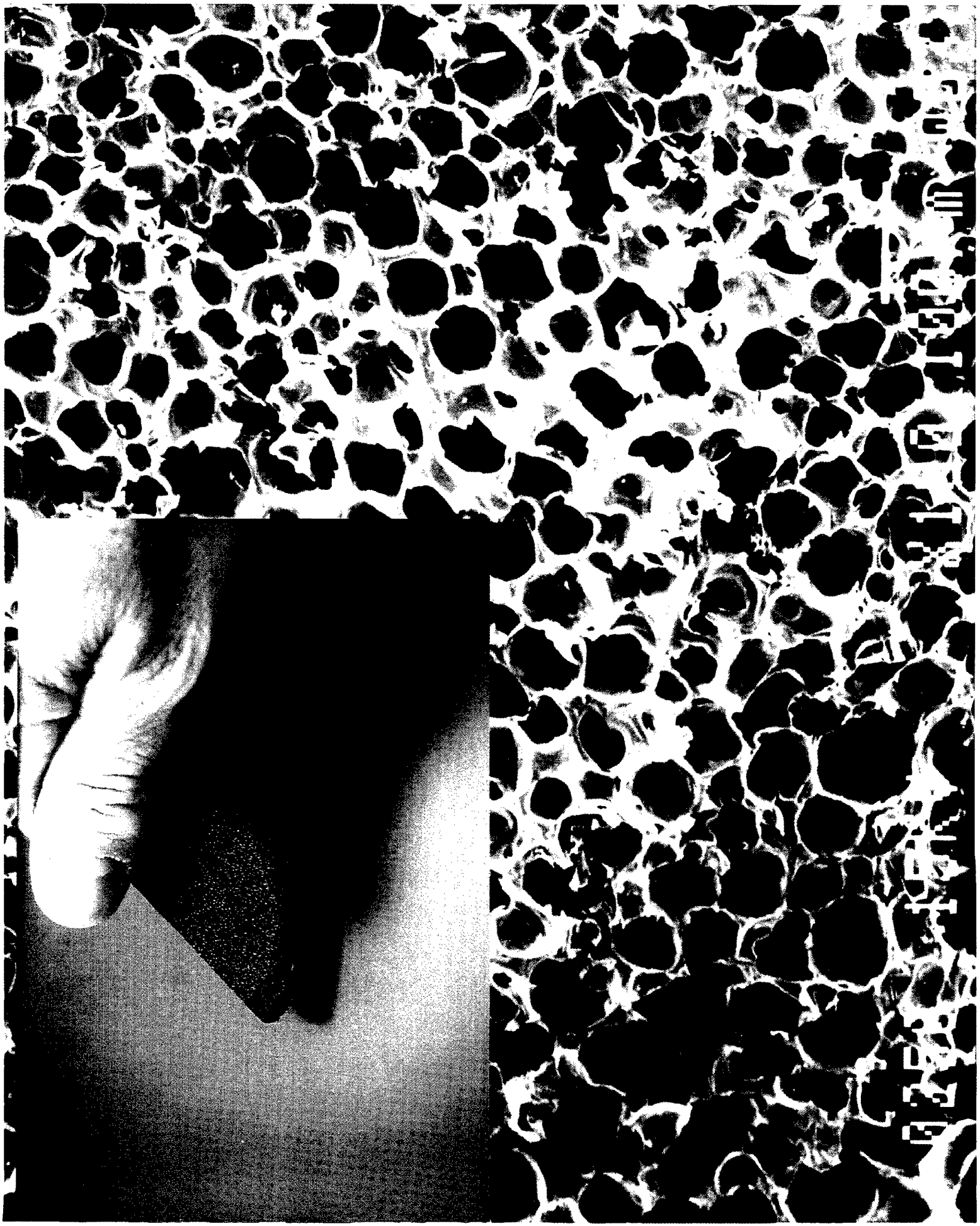
The F-22 flight control system design evaluations, performed in the NF-16D Variable Stability In-Flight Simulator Test Aircraft, will enable the F-22 System Program Office to proceed toward first flight with confidence that the F-22's flight control laws are safe and that the aircraft possesses acceptable flying qualities with an acceptable pilot workload.

Accomplishment

The Flight Dynamics Directorate's Integration Division used the NF-16D Variable Stability In-Flight Simulator Test Aircraft (VISTA) to evaluate the predicted flight characteristics of the F-22 Advanced Tactical Fighter. VISTA produced a highly realistic pilot-in-the-loop in-flight simulation that allowed a detailed and credible evaluation of anticipated flying qualities. Test results revealed no major deficiencies during up and away maneuvering, close formation flight or landing.

Background

The VISTA/NF-16D entered operational service in January 1995 as the Air Force's newest in-flight simulator aircraft. It is operated for the Integration Division by the Calspan SRL Corporation and based at the Greater Buffalo International Airport in New York. Its mission is to support research and development needs by duplicating the flight characteristics of other aircraft, either new ones to be built or generic configurations for research purposes only. The VISTA incorporates a unique combination of production items and has a separate variable stability flight control system into which the flight characteristics to be evaluated are programmed. The center stick and side stick can also be programmed to produce required stick motions and feel characteristics. To simulate the F-22, mathematical models of the F-22's airframe aerodynamics, flight control system and side stick feel characteristics were programmed into the VISTA computers. Test pilots from the Air Force, Lockheed Martin and Boeing evaluated the simulation. They flew realistic tasks that included close formation behind a tanker aircraft, aggressively tracking a moving target and landings in many different turbulence conditions. The real airborne environment that VISTA provides, complete with all the worries, stresses and seat-of-the-pants feel of actual flight, allowed a more realistic evaluation of the anticipated flying qualities of the F-22 than could be achieved in any ground-based simulator.



New Graphitic Foam Material Enables Fast Production for Structural Composites

Payoff

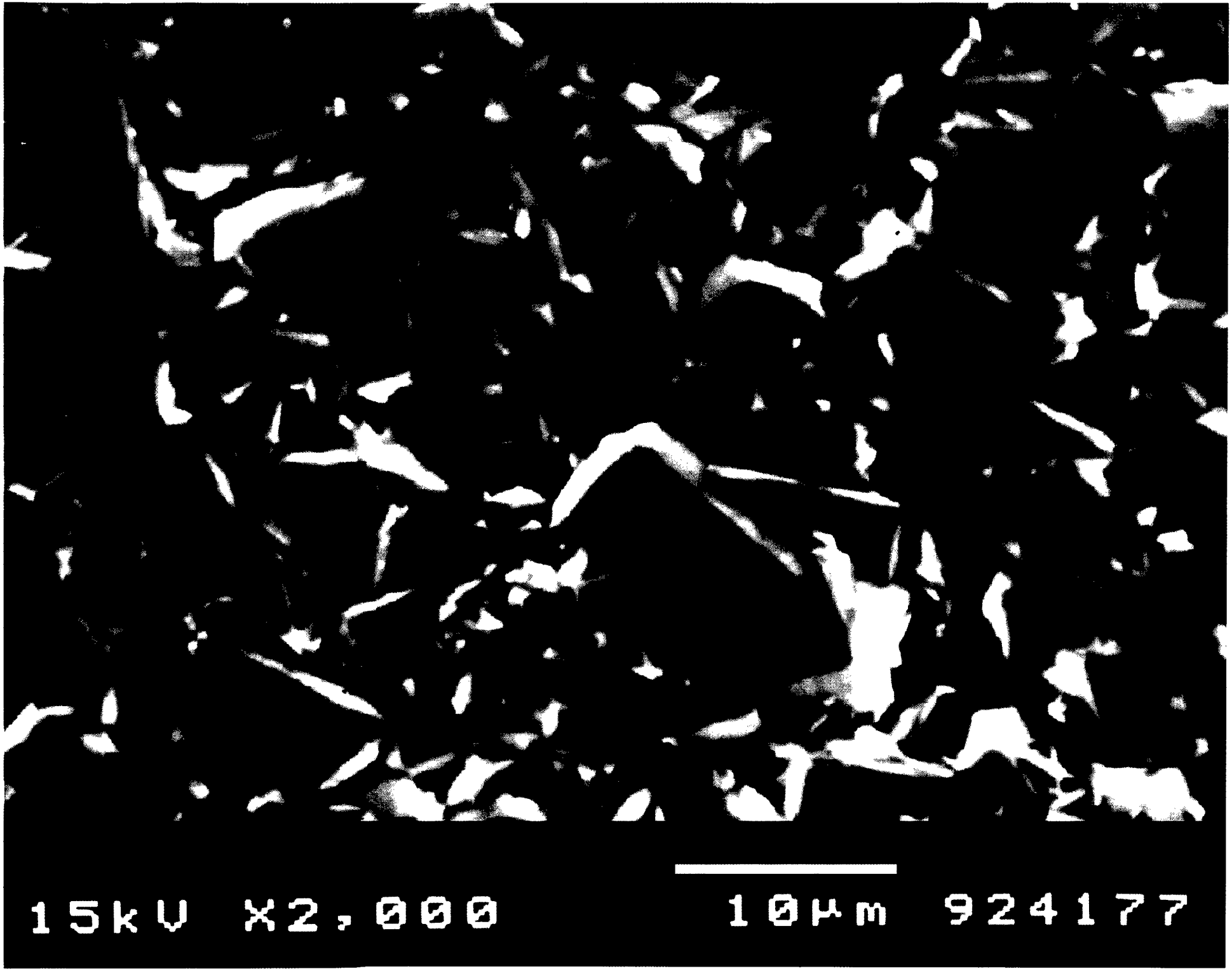
As an ultra-stiff, ultra-lightweight structural material for Air Force aircraft and spacecraft applications, graphitic foam with microcellular structure will provide strength in all directions. Direct, single-step net shape molding of graphitic foam will replace current hand layup or honeycomb adhesive bonding operations, thus reducing manufacturing complexity and cost.

Accomplishment

The Materials Directorate developed a new ultra-stiff, ultra-lightweight graphitic foam composite material that offers three-dimensional isotrophic strength, with physical and performance properties comparable to conventional graphite materials. This open-celled foam, with 90 percent porosity, is projected to have twice the stiffness of aluminum honeycomb and three times the stiffness of composite honeycomb.

Background

Composites for large-area components are typically made of continuous carbon fibers which are laid up by hand into the desired shape with layers of fibers stacked and molded to shape. Composites are also made into honeycomb (bee hive in appearance) cores and covered with a cloth face sheet to produce strong, lightweight panels, with the core adhesive bonded to the face sheet in a separate production step. Most composites for aircraft applications provide strength across the x- and y-axes only, with little or no strength through the z-axis. While offering extraordinary mechanical properties, composite part production is labor intensive, involves multiple steps and is time consuming with finished product costs as high as $500 per pound. While studying ways to exploit the extraordinary properties of aligned graphitic crystallites in carbon and to develop a unique composite reinforcement while reducing manufacturing complexity, the Materials Directorate's initial research led to a material called carbonaceous mesophase pitch, the precursor for most carbon fibers. It was found that a microcellular foamed pitch with 75 percent to 95 percent open-celled structure developed a ligament-like configuration containing the required aligned graphitic crystallites. To achieve a highly uniform microcellular distribution, the pitch is heated to 300° Centigrade and saturated with gas under 1000 psig pressure to dissolve the gas molecules. Following saturation, the pressure is released and the material is rapidly cooled. Direct net shape molding of graphitic foam can eliminate time consuming hand lay-up steps required with continuous fibers. As a replacement for graphitic honeycomb core material, graphitic foam can be molded to the required net shape directly into the face sheet fabric for integral bonding and efficient co-curing, without requiring separate adhesive bonding and molding steps.


15kV X2,000
10µm 924177

Ultra-High Thermal Conductivity Black-Ice™ Substrate Wins 1996 R&D 100 Award

Payoff

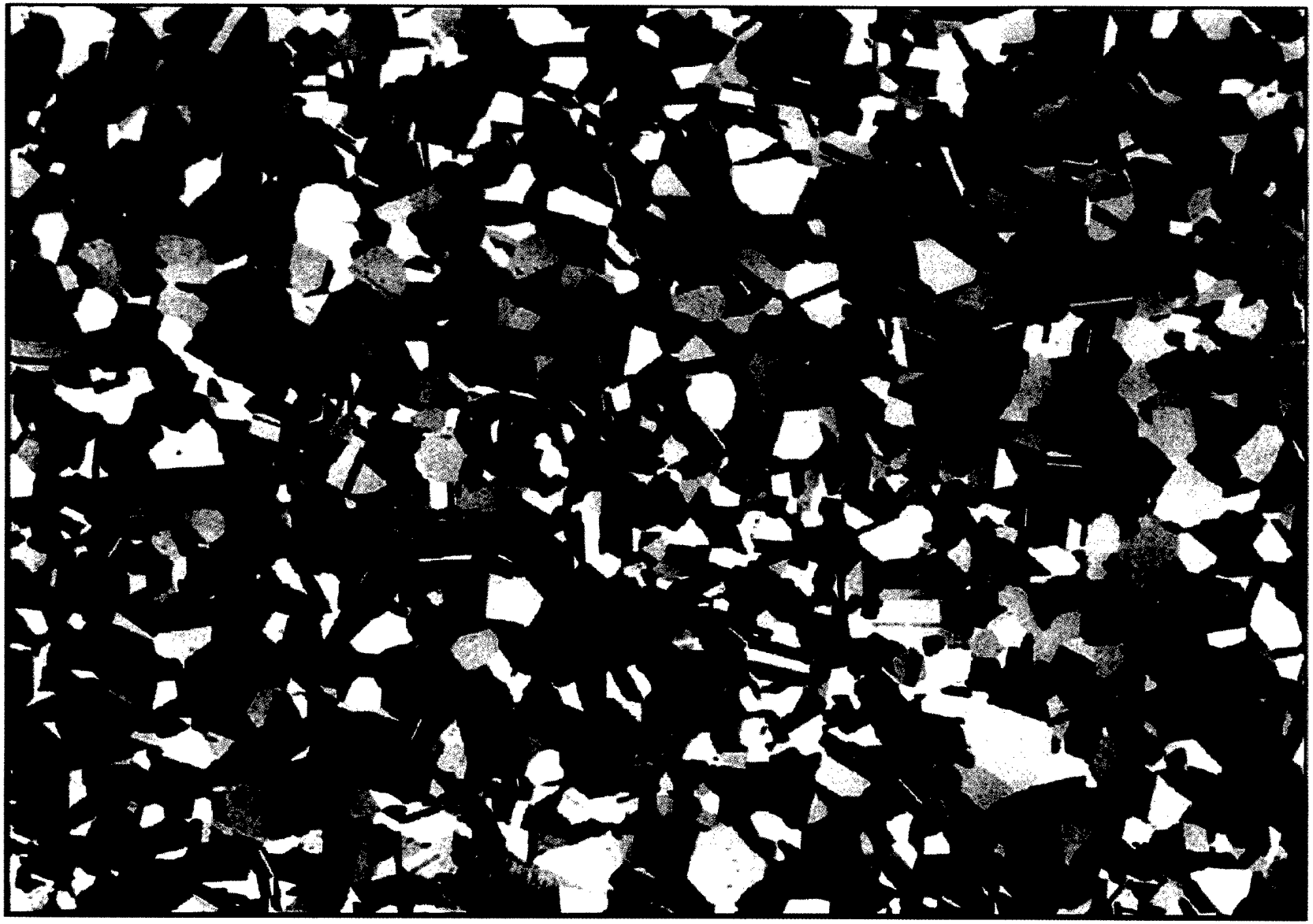
Identified by R&D Magazine as one of the 100 most technologically significant products of 1996, Black-Ice™ composites comprise a low cost technology for heat control in high power or high density electronic packaging. Black-Ice™ substrate materials will allow for the evolution of higher density, higher reliability electronics system designs for telecommunications, computing and automobiles.

Accomplishment

An enhancement of a family of high thermal conductivity substrate materials for use in electronic packaging was recognized by R&D Magazine as one of the 100 most technologically significant products of 1996. This R&D 100 award was given to a team of Applied Science Inc., Aero Propulsion and Power and Materials Directorate personnel. These new substrate materials (Black-Ice™), consisting of a carbon/carbon composite partially infiltrated with chemically vapor-deposited (CVD) diamond in the surface region, have a thermal performance comparable to pure diamond (highest thermal conductivity material) substrate and high electrical resistivity (reciprocal of conductivity).

Background

In the world of electronic packaging, designers turn first to polymers/plastics because of their price and ease of manufacture. These materials, however, exhibit notoriously poor thermal performance, with thermal expansion coefficients as much as ten to twenty times that of silicon, and thermal conductivity as much as 2000-3000 times smaller than Black-Ice™. As a result, in the arena where Black-Ice™ will compete, polymers and plastics cannot compete. Black-Ice™ substrate materials are used in multichip modules (MCM), printed circuit boards and other electronic packaging applications requiring smaller, lighter and cheaper configurations and where controlling heat is a limiting factor. Black-Ice™ substrates are materials which enable more efficient heat removal from electronic circuits than any other available metal, ceramic or composites material, at less than one-twenty-fifth the cost of free-standing diamond films. Black-Ice™ substrate materials are composed of carbon/carbon composites fabricated with a novel, ultra-high thermal conductivity graphite fiber known as vapor grown carbon fiber (VGCF). VGCF/carbon composites were developed under the sponsorship of the Strategic Defense Initiative Organization and the Department of Energy for use in space based power systems and nuclear fusion reactors, respectively. Black-Ice™ is available as an electrical conductor or as a dielectric suitable for metallization and direct die attachment. Dielectric properties of diamond are achieved through thin CVD films of diamond applied to the surface of the composite, to create an integral dielectric heat sink. The thin diamond overlayer, which also infiltrates the carbon/carbon composite, provides both voltage-standoff for electronic components and creates pathways for heat to spread and penetrate into the composite.


200 µm
Forging Direction

"Smart Forging" Process for Gamma Titanium Aluminide Alloys Improves Reliability of Aircraft Turbine Engine Parts

Payoff

Development of the smart forging process for gamma titanium aluminide intermetallic alloys will lower production costs for critical high-temperature components for current and future Air Force weapon systems. The smart forging process reduces production times by up to 90 percent, compared to standard isothermal forging. With this process, aluminide parts possess uniformly fine microstructures, an attribute that helps avoid cracking and fractures and pays off in finished parts that can offer greater operational reliability and capability. Smart forging technology has been transferred to a number of titanium alloy producers and users.

Accomplishment

Research by Materials Directorate scientists and engineers, into the formation of microstructures in gamma titanium aluminide alloys during breakdown metalworking, resulted in a patented, improved forging process. Their "smart forging" process reduces the processing cycle time for aluminides by as much as 90 percent, producing intermediate forged materials with uniformly fine microstructures that are more workable during secondary processing.

Background

Gamma titanium aluminide alloys (aluminides) are intermetallic materials with a balance of low density, excellent stiffness and outstanding operational capability at temperatures as much as 300°C hotter than conventional titanium alloys - a combination of properties much desired for the next generation of Air Force weapon systems. Yet when these materials were first investigated they were found to be quite brittle, exhibiting poor ductility and low fracture toughness at room temperature. Research on ingot processing by the Materials Directorate's Metals and Ceramics Division has paid off in producing aluminides that contain homogeneous microstructures. However, the coarse structure that may result from homogenization of cast ingots can make it easy for cracks to start and propagate through the material. Because of this, the Division investigated the mechanisms that control microstructure evolution and the occurrence of fracture during aluminide breakdown forging. Standard isothermal forging with heated dies typically yields good detail definition on parts, but involves lengthy cycle times due to the uniformly slow ram stroke; in addition, the material microstructures that are developed through standard isothermal breakdown forging tend to be relatively coarse. To enable an increase in ram stroke velocity during forging (ending rate 10 to 100 times faster than the beginning rate), the material was made more workable by utilizing recrystallization to produce finer crystal structures. Smart forging can be used to produce billet stock for the manufacture of gas turbine engine components such as turbine blades, nozzles, engine disks, tiles, cover plates or inner shrouds.


ASD
00372

New Command Post Terminal Provides Secure Communications Link to War Fighter

Payoff

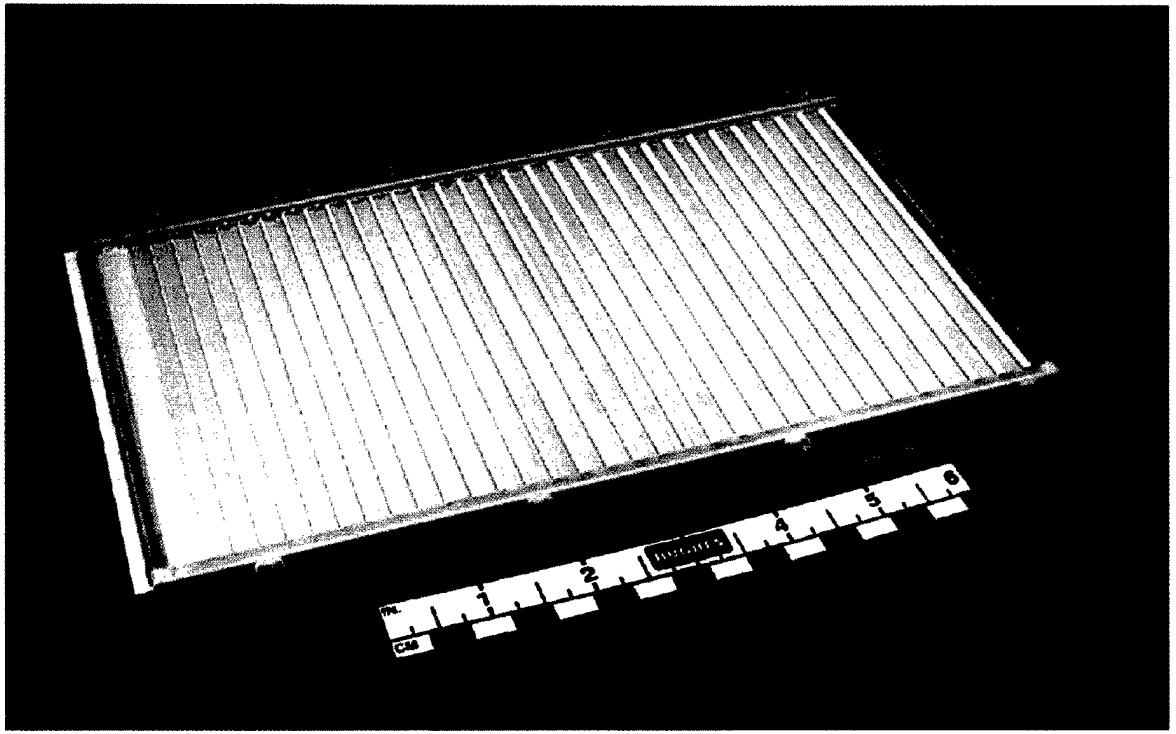
Development and testing of the airborne Milstar satellite communications terminals in the Wright Laboratory C-135 airborne testbed has provided a proven secure, jam-resistant, low probability of intercept command and control communications capability. This new communications system will provide robust, secure and jam-resistant command and control communications to strategic and tactical forces worldwide.

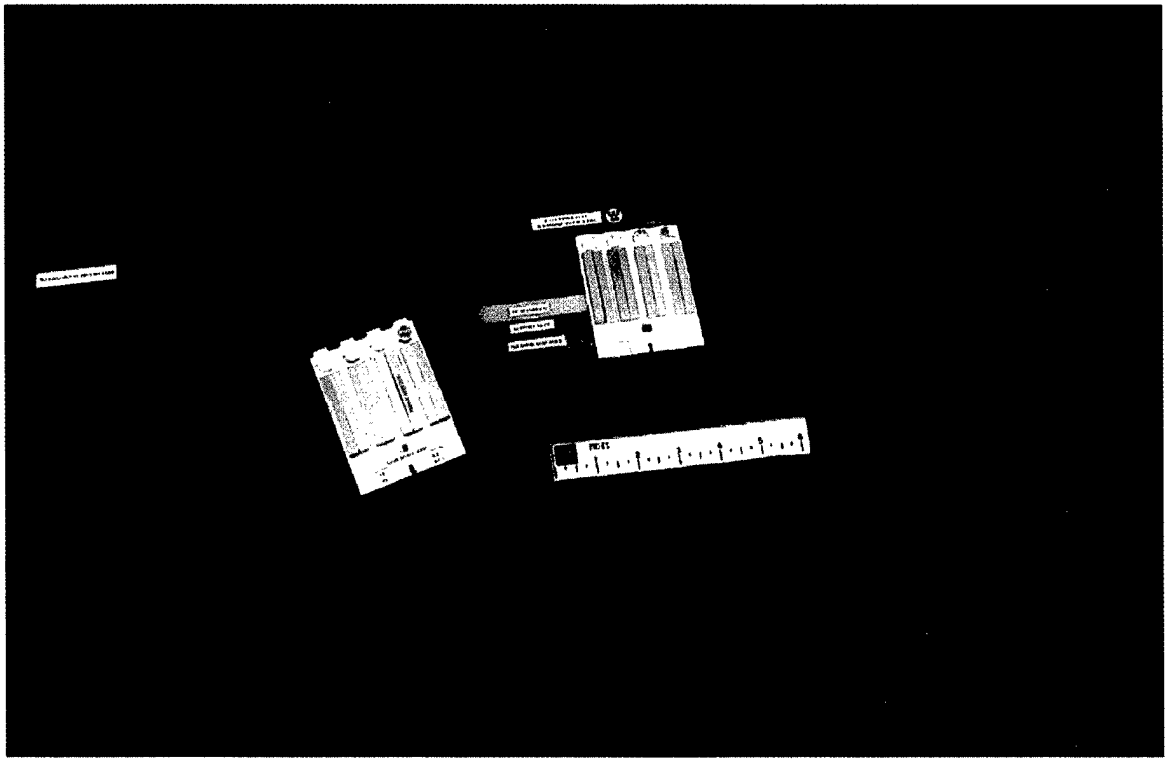
Accomplishment

Technology developed by researchers in the Avionics Directorate was transitioned to the Electronics Systems Center at Hanscom AFB MA to support the development of an operational extremely high frequency (EHF) airborne command post terminal for the next generation military satellite communications system called Milstar. The Directorate participated in the initial feasibility investigation into the use of an EHF band for satellite communications and flight tested the system using Wright Laboratory's C-135 airborne testbed.

Background

Milstar is the Department of Defense's next generation military satellite communications system designed to provide robust, secure and jam-resistant command and control communications to strategic and tactical forces worldwide. The Milstar system is based on an EHF communications capability that provides important anti-jam and low probability-of-intercept features to the war fighter. The Avionics Directorate has been involved in the Milstar program since its inception, developing an advanced development model EHF/Super-High Frequency (SHF) airborne satellite communication terminal. This terminal was used in Wright Laboratory's C-135 airborne testbed to demonstrate EHF technologies over the Fleet Satellite EHF Package in the mid-1980s. The Directorate's researchers began work on the development and testing of this advanced development model airborne command post terminal in the late 1980s. Following the launch of the first Milstar satellite in February 1994, they supported the test and evaluation of the satellite, providing data on satellite antenna pointing errors. This allowed a more accurate pointing of the satellite antennas and optimized the use of the satellite. Following the launch of the second Milstar satellite in November 1995, researchers supported testing of the satellite crosslink, a capability that allows user networks to span multiple satellites without relying on ground relay sites. Wright Laboratory researchers are now involved in the development of an Integrated Tactical Milstar system, which can provide the secure Milstar communications as an add-on for the integrated avionics suite for the use in small aircraft.





New Radar Designs Decrease Cost, Improve Reliability and Performance

Payoff

The new radar system architectures employing advanced antenna designs will nearly double the reliability and detection range of Air Force radar systems, while reducing their production costs by 40 percent. Radar systems will weigh less with increased power.

Accomplishment

Under a program sponsored by the Avionics Directorate, one revolutionary and one evolutionary antenna design were developed by Hughes Aircraft Company and Northrop Grumman that will enhance performance and reduce life cycle cost (LCC) of currently fielded fighter-based systems. In addition, these companies in conjunction with the Air Force, developed a technology development roadmap for practical, affordable radar architectures to reduce the other major cost drivers in current fighter-based radar systems.

Background

The gimbaled antenna of currently fielded fighter-based radar systems is one of the most unreliable line replaceable units. In addition, the gimbaled assembly delays track updates of targets by having to overcome the inertia of the antenna motion. Although electronically scanned array (ESA) antennas do not have this problem, they are expensive to fabricate and typically require additional power and cooling. The studies sponsored by the Avionics Directorate identified the antenna assembly as the number one cost driver in a radar system; it also identified that environmental controls system (ECS) or aircraft shelf modification as the number one limiter for sensor retrofit cost. Both companies took radical but different approaches in developing low-cost radar retrofit architecture concepts. The Hughes antenna solution used a continuous transverse stub array with a voltage variable dielectric material to scan the radar beam in one direction and transmit/receive (T/R) modules to scan in the other. The design reduces the number of T/R modules required versus an ESA by about eighty percent. This radar architecture concept is under consideration for upgrading the F-15E radar system. It would increase performance, reduce LCC and minimize retrofit cost. The Northrop-Grumman design, like Hughes, stays within the ECS service and minimizes aircraft modifications. An important advantage of both antenna designs is that they can be used over a wide variety of applications and frequencies. In addition, manufacturing can be accomplished on existing production lines which lowers non-recurring engineering (NRE) and retrofit radar cost significantly.

Composite Manufacturing Process Control System Reduces/Simplifies Process

Payoff

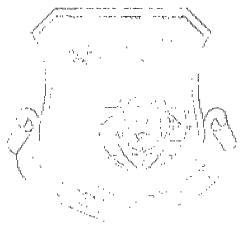
The integrated vision and laser projection system, shown left displaying ply location directly onto a composite layup tool, will reduce development and production costs of composite structures through reduction or elimination of tooling templates, process and inspection steps, production errors and scrap. By eliminating the need for the creation, storage, operation, maintenance and modification of a template, a direct cost savings of $3,500 to $8,000 per month will be realized for a moderately complex hand layed-up, mass produced part.

Accomplishment

Under a Small Business Innovation Research program, sponsored by the Manufacturing Technology Directorate, Assembly Guidance Systems, Inc. developed an integrated vision and laser projection system to automatically deliver dimensional information directly from computer assisted design data. It provides in-process quality monitoring and documentation for the correct sequencing, location and orientation of composite material plies. This proof-of-concept system was installed and operated in a production environment on an F-22 heavy gauge spar preform tool.

Background

Process controls are one of the key elements of building quality into an organic matrix advanced composite structure. Built-in quality reduces inspection, rework and scrap costs, increases reliability and results in lower overall acquisition costs. The majority of process controls investigated to date have focused on the curing process. It has been shown that human error during the lay-up of composite parts, such as mislocated plies, incorrect trimming and placement of incorrect material, can account for 36% of non-conforming parts in production. Rework and scrap are generally attributed to incorrect location and orientation of plies, foreign objects and missing plies. Almost all hand-laid composite parts created today are produced using templates to show the assembler where to place each component in the laminate. These templates are the full size and shape of the part to be produced. The time required to handle them is equal to the time required to lay-up the composite parts. They are cumbersome and expensive to use. The laser and vision prototype system demonstrated by Assembly Guidance Systems eliminates template creation, storage, operation errors, maintenance and modification and all associated labor. This automatic in-process monitoring system catches production problems at the point where they can be resolved with minimal or no cost. Costs are reduced through scrap and rework reductions.



New Hydraulic Fluid Improves Safety for B-1B Bombers, KC-135 Tankers, Radar and Reconnaissance Aircraft

Payoff

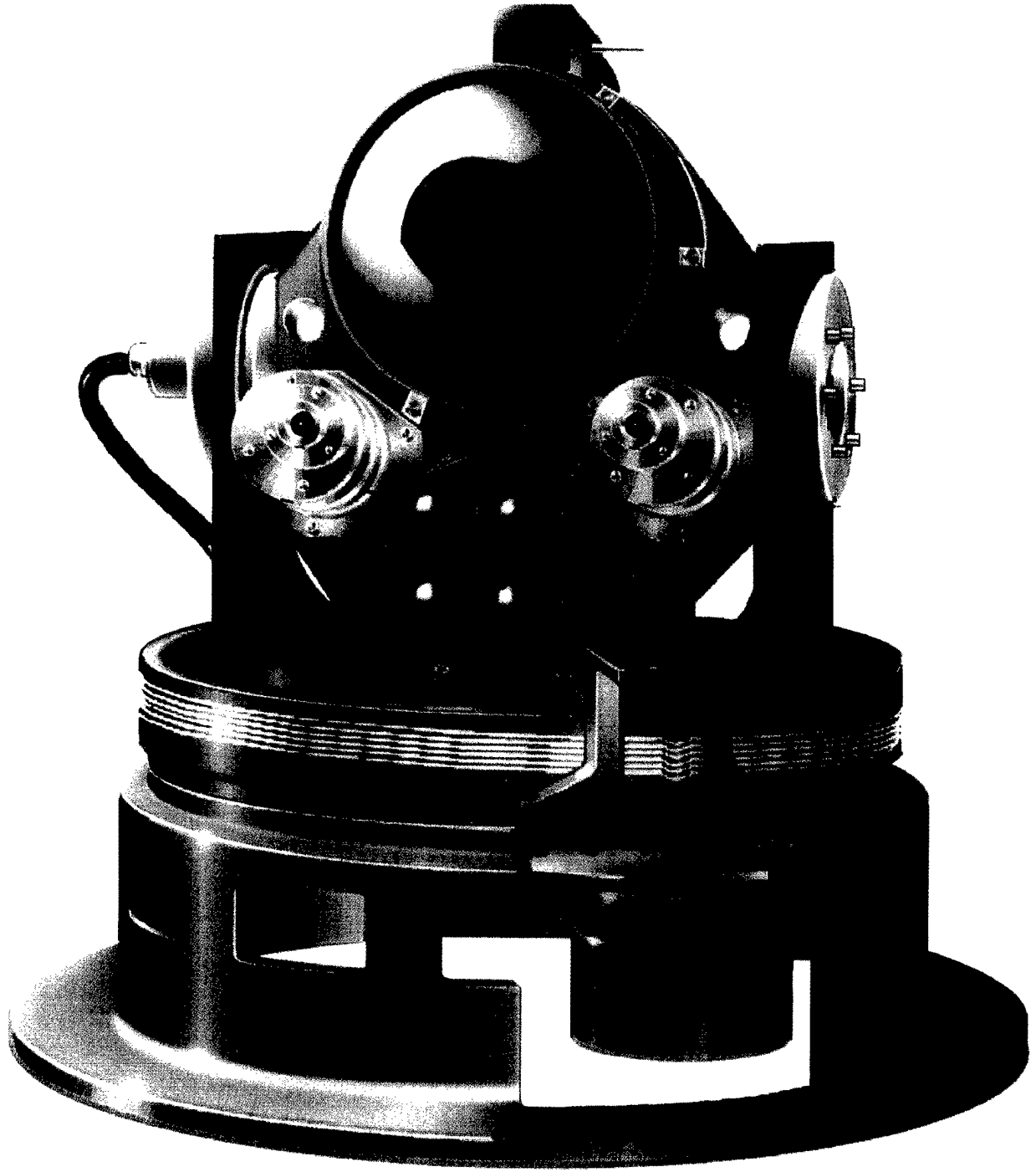
The new hydraulic fluid, MIL-H-87257, offers increased resistance to fire ignition, as well as, greatly improved lubricity, compared to the conventional, more flammable petroleum based fluid. By providing a greater margin of safety for B-1B bombers, KC-135 tankers and radar and reconnaissance aircraft, losses due to hydraulic fires can be reduced by as much as 95 percent. Crew safety is enhanced, as well as, aircraft mission readiness.

Accomplishment

A fire-resistant hydraulic fluid developed by researchers at Wright Laboratory's Materials Directorate has been accepted for use in Air Combat Command's (ACC) B-1B bombers, as well as, KC-135 tankers, radar and reconnaissance aircraft serving ACC. This fluid, MIL-H-87257, features an operating temperature range broad enough to permit rapid warm-up in polar conditions.

Background

Hydraulic systems perform many vital jobs in aircraft today, such as, raising and lowering the landing gear, applying wheel brakes and controlling personnel access and cargo loading doors. Yet, ever since hydraulic systems using petroleum-based hydraulic fluid were added to aircraft, flammability has been a hazard. By the early 1980s, aircraft fire damage attributable to hydraulic fluid cost the Air Force an average of $20 million annually. At that time, a fire-resistant hydraulic fluid, MIL-H-83282 with an operating range of -40°F to +275°F, was adopted by many Air Force aircraft. However, ACC bombers and their support aircraft (KC-, EC-, RC-135) needed the ability to start, warm up, taxi and get into the air quickly in temperatures as low as -65°F. Thus, they were granted a waiver to continue using the older, more flammable petroleum-based fluid. Hydraulic fire damage dropped to under $1 million per year in the 80 percent of the Air Force fleet equipped with fire-resistant fluid. Meanwhile, the Materials Directorate developed, formulated and tested a new fire-resistant hydraulic fluid, MIL-H-87257 with a flash point above 300°F. This fluid features an operating range of -65°F to +275°F, within ACC requirements, and offers very good lubricity (capacity to reduce friction) to help maintain pumps and actuators throughout the hydraulic system. The Oklahoma City Air Logistics Center agreed to test MIL-H-87257 in the B-1B bomber following extensive ground tests. After a year of testing, during which the fluid performed successfully under a broad range of cold and hot conditions, an evaluation of the B-1B's system pumps showed them to be in compliance with new pump specifications. Based on these results, a decision was made to convert all B-1Bs in the Air Force fleet to MIL-H-87257 fluid. Similar tests with KC-135 tankers flown for a year in a range of extreme conditions resulted in a Air Force decision to convert the entire KC-135 fleet.



Laser Communications and Inertial Navigation Equipment Combined to Offer High Bandwidth Data Link Capability

Payoff

The integration of laser communications and inertial navigation equipment will provide the technology to meet projected high bandwidth data link requirements for future reconnaissance missions that are anticipated to be four times the capability of current radio frequency links.

Accomplishment

Researchers in the Avionics Directorate, working jointly with the Defense Airborne Reconnaissance Office, demonstrated in a simulated flight environment, the feasibility of using laser communication equipment integrated with existing inertial navigational equipment to relay sensor information by data link from one aircraft to another aircraft not in the immediate area. New "pointing" software was developed that enabled the inertial and laser communication systems to interact effectively.

Background

Reconnaissance aircraft are frequently required to relay sensor information by a data link to another aircraft not in the immediate area. A successful exchange of information is dependent on knowing the exact locations of sending and receiving aircraft. Pilots currently rely on preprogrammed data and their inertial system to provide the information needed to calculate their aircraft's location. The exact locations of aircraft will become more important as future missions use high bandwidth laser communications systems instead of the bandwidth limited radio frequency equipment of today. With existing laser communication systems, aircraft must find each other within a small one-and-a-quarter degrees by one-and-a-quarter degrees "window" of airspace for successful laser communication equipment linkage. To integrate laser communication equipment with existing front-line inertial systems, new software was developed for the gimbaling and control systems that enabled the systems to interact effectively. After ascertaining that operational inertial systems using this software can place an aircraft within the desired window, the two technologies were combined to determine whether the integrated laser communications system would find, track and transmit data to receiving equipment in another aircraft. The validation was performed under a program sponsored by the Avionics Directorate with Thermo Trex Corp. and Loral. An aircraft environment was simulated by placing the equipment on a moving and vibrating motion base that emulated the flight motion and vibration of an aircraft. After the inertial reference system correctly calculated the aircraft position within the airspace window, the laser communications system took over, steered the system linking the two systems together and tracked and transmitted data to a receiving laser communications system 92 miles away.

WRIGHT LABORATORY SIGNS 100TH COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT

Payoff

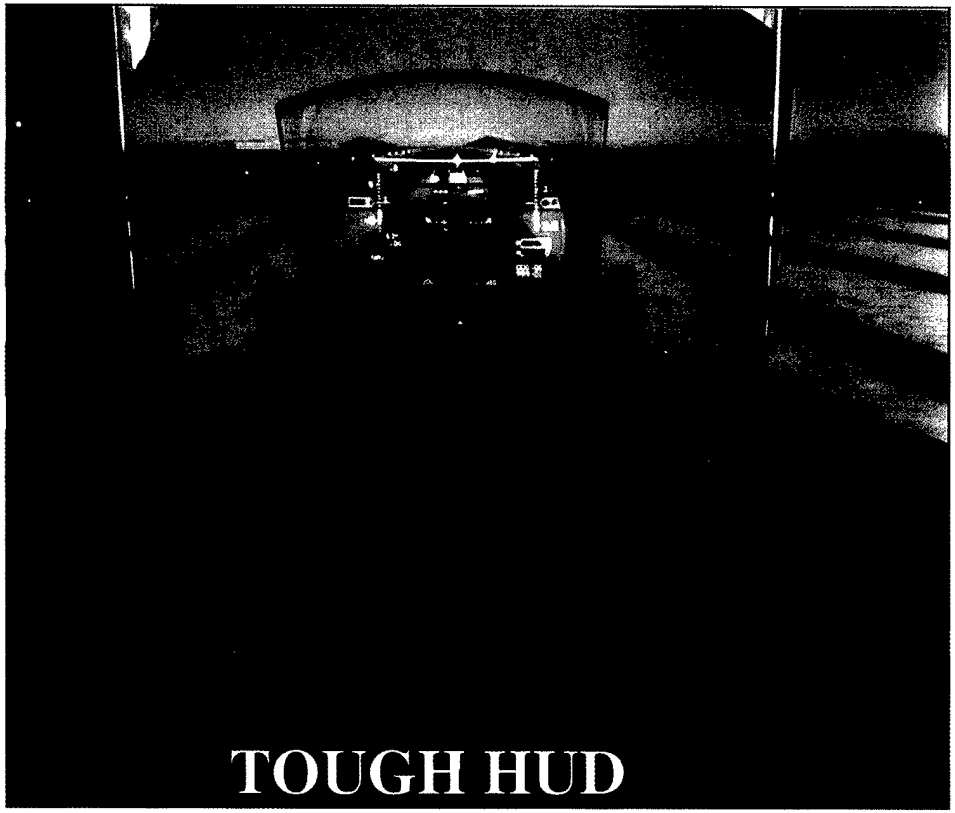
The 100th Cooperative Research and Development Agreement will enhance the design, performance, quality and quantity of nonlinear optical (NLO) devices for Air Force multichip module applications. This will be accomplished through the increased availability of a new NLO polymer material and the utilization of new fabrication processes. This cooperative project will also assist American industry to be more competitive in the world marketplace.

Accomplishment

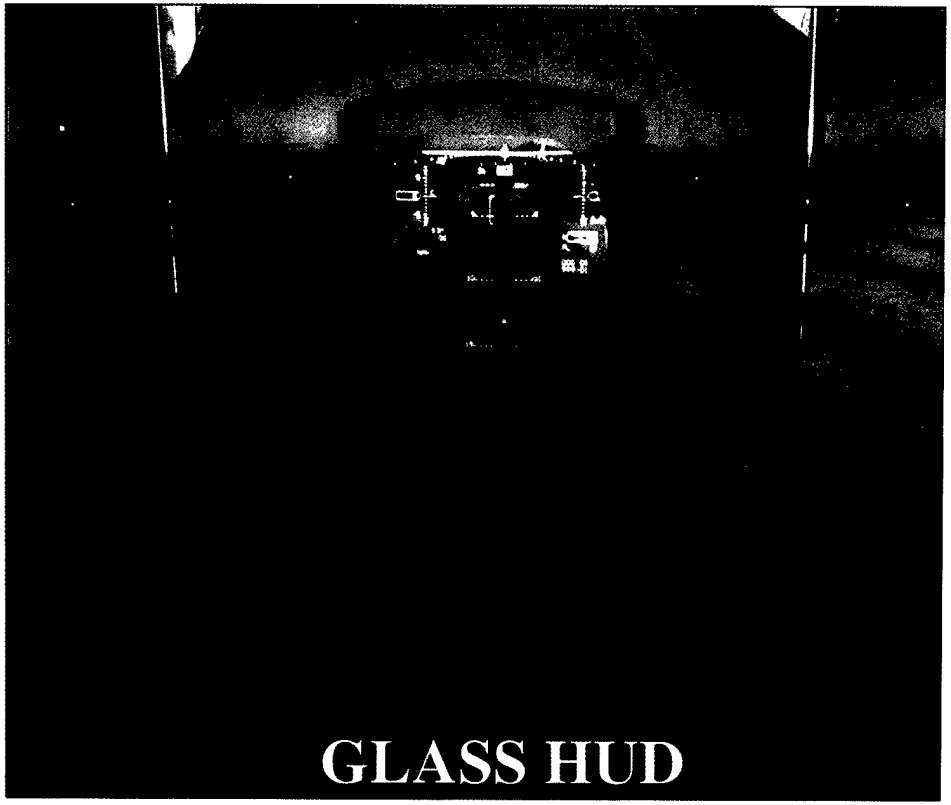
Colonel Richard Davis, Wright Laboratory Commander, and Dr. Jesse Ryles, Avionics Directorate Director, participated on 29 May 1996 in the formal signing of Wright Laboratory's 100th Cooperative Research and Development Agreement (CRDA). This CRDA with AdTech Systems Research Inc. of Beavercreek OH will enhance the performance, lower the cost and improve the production process of NLO devices.

Background

NLO technology has been around since the turn of the century, but development has been restricted by the difficulty in synthesizing quality polymer materials and developing reliable and repeatable production processes. Because of high cost and performance limitations of current NLO polymer technology, no devices have been commercialized for multichip modules. Using un-optimized NLO polymers, designs and conventional fabrication methods for opto-electronic polymers devices, manufacturers today are producing devices 1.5 to 2 centimeters long, which are too large for Air Force multichip module applications. Using a new optimized, organic material (AdTech's LD-3, NLO polymer material), enhanced opto-electronic device designs and new fabrication processes will help solve many of these problems. Because this new NLO polymer technology provides a significant increase in capability, an advanced system will emerge as complementary devices are developed to take advantage of these nonlinear properties. LD-3 produced by AdTech has increased nonlinearity, which means that when it is used in opto-electronic devices, less voltage is required to "switch" the device on and off. LD-3 material synthesis costs have been reduced dramatically. LD-3 can be processed using standard electronic fabrication equipment. One goal of the CRDA is to demonstrate an array of opto-electronic switches that fit within a 5 millimeter by 5 millimeter square to allow for their use within electronic multichip modules. This means that instead of making a 2-centimeter-long device, a device one-tenth that size will be produced.



TOUGH HUD



GLASS HUD

TOUGH HEAD-UP DISPLAY (HUD) HAS ADVANTAGES FOR F-22

Payoff

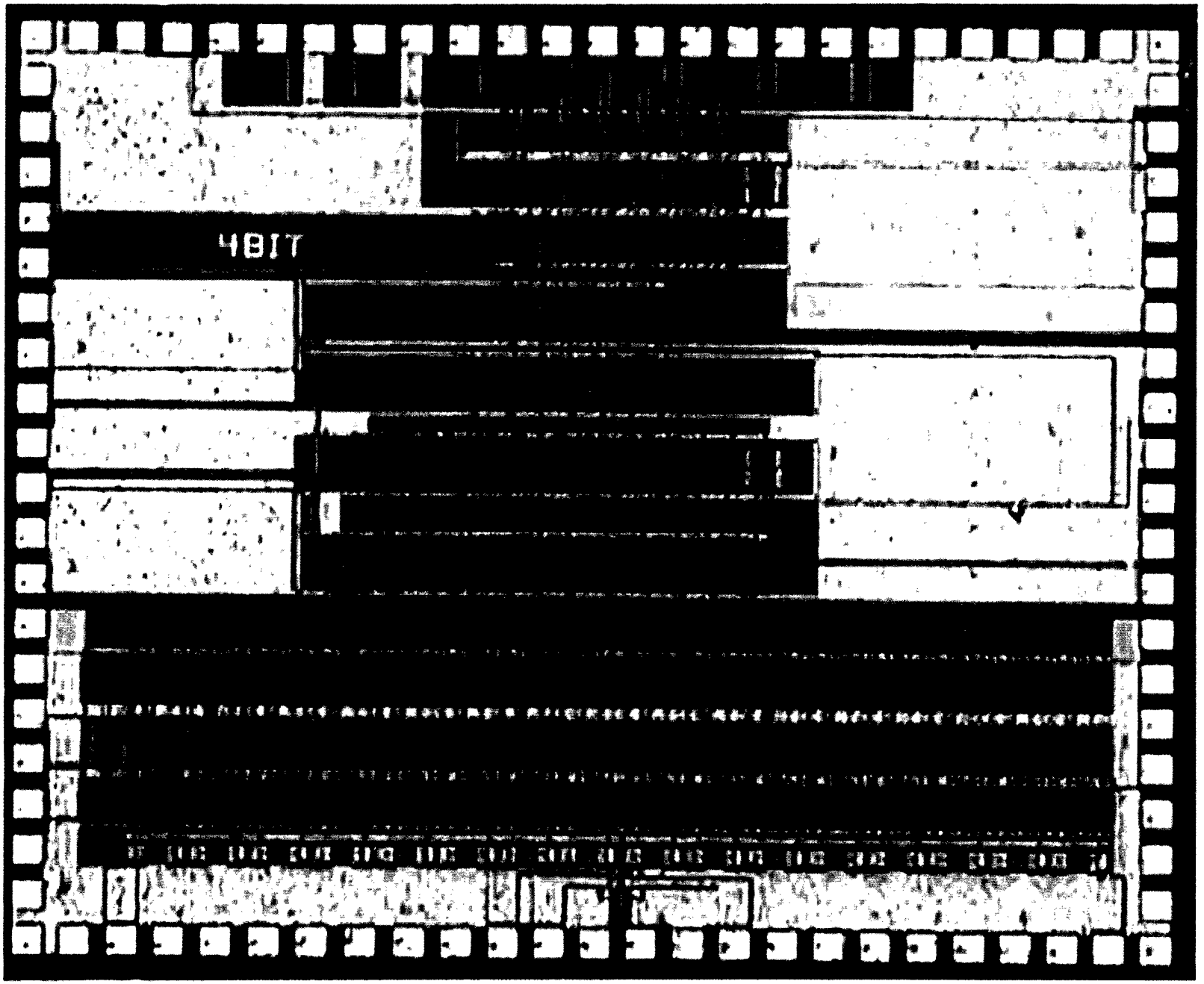
The tough HUD solution to the birdstrike protection problems inherent to the glass HUDs currently used, will increase aircrew safety without increasing system weight or decreasing optical quality. Simplified attachment concepts and manufacturing processes coupled with lower material costs will provide a 50 percent cost savings.

Accomplishment

The Flight Dynamics Directorate's Vehicle Subsystems Division demonstrated the adequacy and feasibility of the reflective and anti-reflective coating, birdstrike capability and design for an all polycarbonate HUD for the F-22 aircraft canopy system. A mock-up F-22 transparency/ HUD configuration was subjected to a birdstrike at 350 knots and prevented penetration (the HUD did not release fragments); although, the transparency deflected and struck the HUD.

Background

As aircraft transparency systems have become more effective at preventing birdstrike penetrations, an impact resistant HUD glass has emerged as a limiting factor in providing protection for aircrews. When a transparency deflects and strikes such a HUD, two undesirable events can occur. The glass can break and shatter into many small sharp projectiles and injure the pilot, and the canopy/HUD interaction can cause transparency failure due to premature crack initiation. The best conventional approach to the F-22 System Program Office's (SPO) birdstrike challenge is a HUD/transparency rub strip designed to protect the canopy from failure due to interaction with a shattered HUD. However, this design's limitations allow for little or no canopy deflection, causes pilot vision obscuration, adds weight and does not address the SPO's stringent incapacitating injury requirement. The SPO's stringent commitment to an all plastic HUD as long term solution is reflected in their teaming with the Flight Dynamics Directorate, GEC Marconi Avionics and the University of Dayton Research Institute to achieve significant risk reduction in combiner technology.


4BIT

Advanced InP Heterojunction Bipolar Transistor Technology Increases Bandwidth Sampling

Payoff

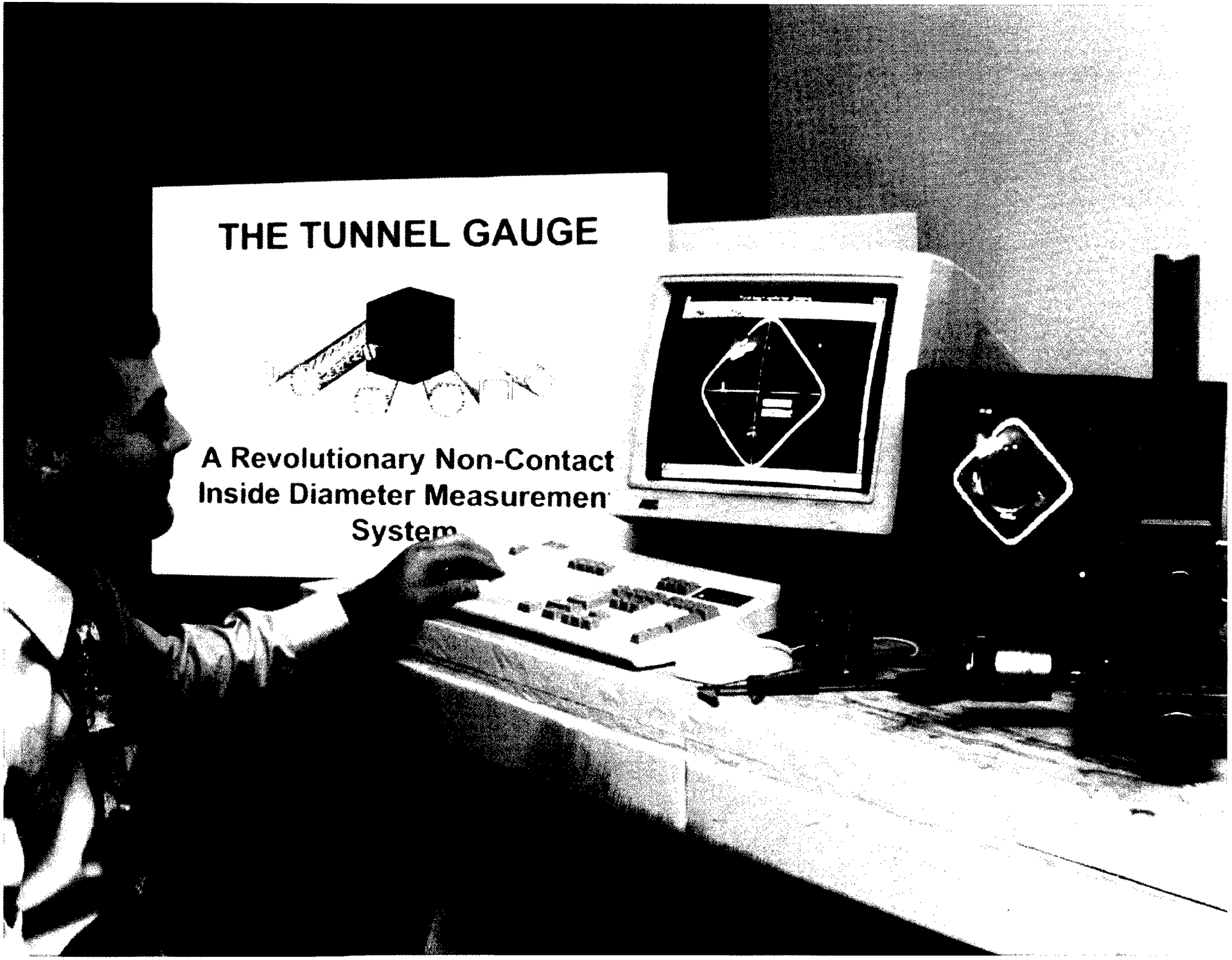
The new indium phosphide (InP) heterojunction bipolar transistor technology, used to fabricate the 4-bit analog-to-digital converter (ADC) shown left , has made it possible to look at new radar, communication and electronic warfare receiver architectures. ADCs employing this new technology will enable a more accurate sampling of incoming signals with much larger instantaneous bandwidths.

Accomplishment

Under the sponsorship of the Avionics Directorate's Electronic Devices Division, Hughes Research Laboratories developed a new InP heterojunction bipolar transistor (HBT) technology that demonstrated a cutoff frequency (figure of merit used to compare technologies) of 170 gigahertz (a greater than 2 fold improvement over their baseline process) and was used to fabricate two ADCs. Speeds obtained with these ADCs (3-bit ADC operating at 8 gigasamples per second and a 4-bit ADC operating at 10 gigasamples per second) represent the state-of-the-art in monolithic semiconductor ADCs.

Background

An ADC is a common device to both military and commercial applications and is used when there is a requirement to process real world data with a digital processor. There is an ever increasing demand for ADCs to handle higher bandwidth information with increasing accuracy. This demand is dictated by the trends in radar, electronic warfare and communications systems to move the digital interface closer to the sensor/ antenna, thereby, reducing or completely eliminating the analog down conversion stages. These analog functions (typically consisting of filters, local oscillators and mixers to reduce the frequency of the incoming signal down to a point where it can be sampled by a low speed ADC for further processing) are bulky, costly and require considerable recalibration as they drift over temperature. InP HBT technology provides the means for achieving the very high sampling rate ADCs require to move the digital interface closer to the source. This technology, which is applicable to many high speed applications, is also being applied in conjunction with bandpass delta-sigma ADC technology to address the higher resolution needs of radar receivers. It is enabling system designers to investigate receiver architectures which were not previously feasible. The F-15, B-2 and F/A-18E/F programs are considering receiver upgrades due to increased emphasis to reduce acquisition and life-cycle costs and to extend platform life by increasing avionics capability.


THE TUNNEL GAUGE
A Revolutionary Non-Contact
Inside Diameter Measuremen
System

New Laser Probe Enhances Manufacturing Processing

Payoff

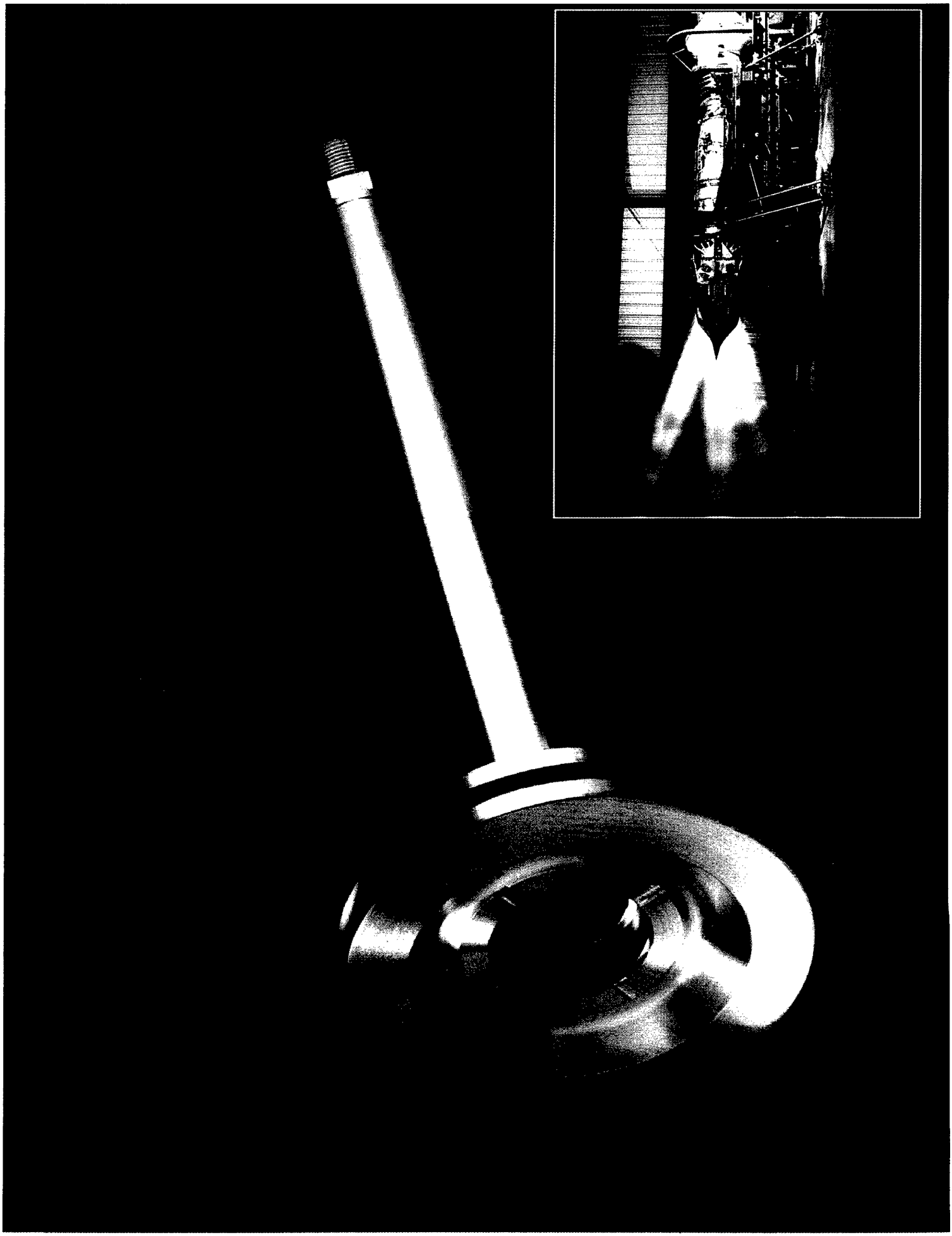
The tunnel gauge system provides a non-contact, non-destructive laser probe that can be used as a statistical process control unit in manufacturing tubular parts. It gives manufacturers a tool to collect dimensional data quickly, accurately and repeatably, thus reducing cost and scrap and enhancing product quality.

Accomplishment

Under a Cooperative Research and Development Agreement between the Avionics Directorate and Gauge and Measurement Technologies Ltd. of Dayton OH, a laser probe to accurately measure the inside dimensions of tubular structures was developed. This probe is part of a tunnel gauge system that includes image capturing electronics and a computer for data storage.

Background

One of the most difficult manufacturing evaluation processes is the accurate measurement of the inside of tubular structures. Without reliable data, manufactured parts might not meet standards and have to be scrapped. Gauge and Measurement Technologies relied on the Avionics Directorate's experience in the design of electro-optical systems to assist them in designing a laser probe to solve this problem. Their collaboration resulted in a tunnel gauge system that used a laser to triangulate the inside dimensions of tubular structures. Measurement probes can be as small as 1/2 inch in diameter, allowing for measurement of parts with minimum internal diameters of five-eighths inch. Any set of two-dimensional characteristics in a cross-sectional plane can be captured and analyzed. The probe is designed for off-line use in a laboratory or on the factory floor and for in-line use on a rolling mill, extruder or similar continuous production process. It can provide closed-loop feedback to the production machine, allowing for real-time production control. Because the measurement probe is non-contact, it is particularly valuable in applications where contact with the part may cause variations in the measurement or where contact may damage the part. Unlike most mechanical gauges, the probe does not rely on human feel, positioning or interpretation of the results. Since all data is electronically captured, variances due to human intervention or human error are eliminated.



Low Cost Manufacturing Process Scalable to Rate Production for the F-22 Nozzle Component

Payoff

Through the F-22 Engineering Manufacturing Development Program, a process was developed which will enable an Integrated Product Team to meet the manufacturing cost goal of $1,200 (as compared to $8,000 today) at the 500th unit for the titanium matrix composite (TMC) actuator piston rod in the F-22's two-dimensional nozzle. The TMC actuator piston rod, which will have mechanical properties that exceed requirements by a factor of eight, will be the first application of titanium matrix composite in a production weapon system.

Accomplishment

An Integrated Product Team (IPT) led by both the Manufacturing Technology Directorate and the F-22 System Program Office established a low cost manufacturing process which is scalable to high rate production for the fabrication of TMC nozzle components for the F-22 aircraft. An application of this process resulted in reduced manufacturing costs and improved reproducibility for the TMC actuator piston rod in the two-dimensional nozzle of the Pratt & Whitney F119 engine.

Background

The two-dimensional nozzle in the Pratt & Whitney F119 engine uses flaps to divert jet engine exhaust in many directions, increasing the performance and maneuverability of the aircraft. Two dimensional nozzles are typically heavier than their axisymmetrical counterparts. To achieve the extraordinary maneuverability and speed response required for new generation aircraft, lightweight, high temperature components with high specific stiffness/strength are required. The objective of this effort was to establish a low cost manufacturing process which is readily scalable to high rate production for the fabrication of TMC nozzle components.

Through the IPT, that included members from Pratt & Whitney, Parker Aerospace, Atlantic Research Company and the Wright Laboratory Aero Propulsion and Power, Manufacturing Technology and Materials Directorates, all elements of the product's design-cycle, including quality, cost, schedule and user requirements were considered. The information gathered guided the definition of a mature process technology path to facilitate the transition from advanced technology demonstration to production. In February 1996, the F-22 System Program Office gave approval to flight test the TMC actuator piston rod.

Acronym List

Acronym	Definition
AAPT	Aircraft Avionics Packaging Technology
ABDR	Aircraft Battle Damage Repair
ACC	Air Combat Command
ACTIVE	Advanced Control Technology for Integrated Vehicles
ADC	Analog-to-Digital Converter
AEC	Aviation Environmental Compliance Inc.
AFA	Air Force Association
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AMRAAM	Advanced Medium Range Air-To-Air Missile Reliability
ANG	Air National Guard
AOE	Automated Ordnance Excavator
BIT/FIT	Built-In Test/Fault Isolation Test
BMDO	Ballistic Missile Defense Organization
BSN	Barium Dinonylnapthalene Sulfonate
CAD/CAM	Computer-Aided Design/Manufacturing
C-C	Carbon-Carbon
CFRP	Carbon Fiber Reinforced Polymer
CHAMP	Configurable-Hardware Algorithm Mappable Preprocessor
CRDA	Cooperative Research and Development Agreement
CVD	Chemically Vapor-Deposited
DB	Decibels
DES	Dynamic Environment Simulator
DICE	Data Integration and Collection Environment
DIS	Distribution Interactive Simulation
DLC	Diamond-Like Carbon
DRA	Discontinuously-Reinforced Aluminum
ECLM	Expert Communications Link Manager
ECS	Embedded Computer Systems
ECS	Environmental Controls System
EHF	Extremely High Frequency
ELABRAT	Electrically Actuated Brake Technology
ESA	Electronically Scanned Array
ESAD	Electronic Safe and Arm Device
EW	Electronic Warfare
FLUMES	Fluid Mechanics of Screech
FPGA	Field Programmable Gate Array
FWD	Falling Weight Deflectometer
GEMMA	Growth in Education Through a Mathematics Mentorship Alliance
GHz	Gigahertz
HBT	Heterojunction Bipolar Transistor
HQ AFSOC	Headquarters Air Force Special Operations Command
HTS	High-Temperature Superconducting
HUD	Head-Up Display
HWD	Heavyweight Deflector
HZ	Hertz
IBP	Industrial Base Pilot
IDG	Integrated Drive Generator
IF	Intermediate Frequency
IHPTET	Integrated High Performance Turbine Engine Technology
IMMO	Integrated Materials Management Office
INP	Indium Phosphide
IPT	Integrated Product Team
IR	Infrared
JAST	Joint Advanced Strike Technology
LCAC	Land Craft Air Cushioned
LCC	Life Cycle Cost
LIDAR	Laser Detection and Ranging
LTCC	Low Temperature Co-Fire Ceramic
MAUS	Mobile Automated Scanner
MCM	Multichip Modules
MERIT	Mission Environmental Requirements Integration Technology
MITS	Mission Integrated Transparency System
MPM	Microwave Power Module
NASA	National Aeronautics and Space Administration

(Continued on next page . . .)

Acronym List

Acronym	Definition
NDCEE	National Defense Center of Environmental Excellence
NGT	Next Generation Transparency
NLO	Nonlinear Optical
NRE	Non-Recurring Engineering
ODOT	Ohio Department of Transportation
OFP	Operational Flight Program
OO-ALC	Ogden Air Logistics Center
OTMC	Orthorhombic-Based, Titanium Aluminide Matrix Composite
PBO	Polybenzoxazole
PBT	Polybenzothiazole
PLD	Pulsed Laser Deposition
PMC	Polymer Matrix Composite
PPLN	Periodically Polled Lithium Niobate
PROTEC	Programmable Ordnance Technology
RASCAL	Radiation and Scattering Compact Antenna Laboratory
RCS	Radar Cross Section
RF	Radio Frequency
RWD	Rolling Weight Deflectometer
SA-ALC	San Antonio Air Logistics Center
SATCOM	Satellite Communications
SAWS	Silent Attack Warning System
$SCCO_2$	Supercritical Carbon Dioxide
SDC	Self-Directed Control
SEM	Standard Electronic Modules
SHF	Super-High Frequency
SOF	Special Operations Forces
SPO	System Program Office
SSPA	Solid State Power Amplifier
STTR	Small Business Technology Transfer
SWE	Society of Women Engineers
TCA	Trichlorethane
TMC	Titanium Matrix Composite
T/R	Transmit/Receive
TSHBT	Thermally Shunted Heterojunction Bipolar Transistors
T21	Thermal Technologies Inc.
TWTA	Traveling Wave Tube Amplifier
USAC	United States Auto Club
UV	Ultraviolet
UXO	Unexploded Ordnance
VDC	Volts Direct Current
VGCF	Vapor Grown Carbon Fiber
VISTA	Variable Stability In-Flight Simulator Test Aircraft
VM	Virtual Manufacturing
VSA	Variation Simulation Analysis
VSIM	Velocity Simulation
WIG	Women in Government
WR-ALC	Warner Robins Air Logistics Center
YIG	Yttrium Iron Garnet

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